

GIVE A DOG A PHONE
Technology for our furry friends

NewScientist

WEEKLY November 29 - December 5, 2014

We've made
150,000 new chemicals



We touch them,
we wear them, we eat them

But which ones should
we worry about?

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THE GOOD FIGHT

Most violence
is also virtuous

CHAMBER OF SECRETS

The greatest ever find
of early human bones

IS IT ALIVE?

Artificial worm could
be first digital animal





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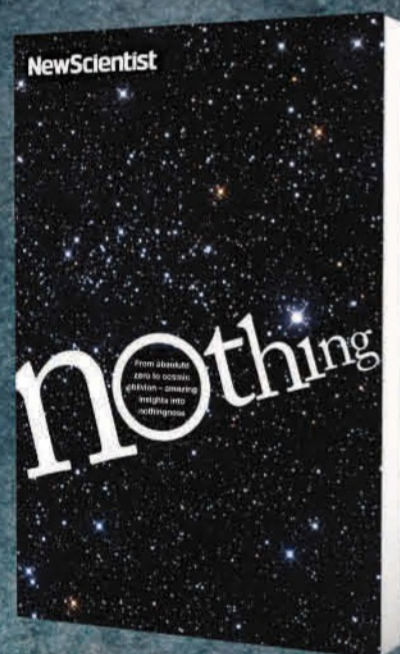
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One year subscription (51 issues) \$154

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Newsstand

Tel 212 237 7987
Distributed by Time/Warner Retail
Sales and Marketing, 260 Cherry Hill
Road, Parsippany, NJ 07054

Syndication

Tribune Content Agency
Tel 800 637 4082

© 2014 Reed Business
Information Ltd, England.

New Scientist ISSN 0262 4079 is
published weekly except for the last
week in December by Reed Business
Information Ltd, England.

New Scientist at Reed Business
Information, c/o Schnell Publishing Co.
Inc., 225 Wyman Street, Waltham,
MA 02451.

Periodicals postage pending at
Boston, MA and other mailing offices.

Postmaster: Send address changes
to New Scientist, PO Box 3806,
Chesterfield, MO 63006-9953, USA.

Registered at the Post Office as a
newspaper and printed in USA by Fry
Communications Inc, Mechanicsburg,
PA 17055



CHRIS RYAN/GETTY

Detoxify the c-word

"Chemical" is becoming a dirty word. That needs to change

IN THE late 1990s, rumours began to circulate that a chemical used liberally both in homes and in factories was associated with many perils. It was said to be fatal if inhaled, capable of causing severe burns – and a major constituent of most tumours.

You've probably guessed the punchline already. The suspect substance was dihydrogen monoxide – aka water. Originally an April Fool gag, this meme has persisted, a perennial reminder of how willing people are to fall for scare stories about "chemicals".

This chemophobia has much in common with other modern fears. Like radiation, chemicals are all around us, their effects (if any) pernicious yet invisible; like genetically modified organisms, they are mostly created by firms with profit in mind, rather than social good. There is also the

enduring public memory of the many synthetic chemicals withdrawn when they turned out to be toxic – think asbestos, DDT, tetraethyl lead and more.

But wait. Sure, a handful of synthetic chemicals have proven harmful. But many are safe when properly used and managed. Still more are harmless and extraordinarily useful. A world emptied of them would be filled instead with dirt, drudgery, deprivation and disease.

Clearly we need to be vigilant, but we should take care to weigh up the pros and cons. For that, we need a better-informed public debate. More research would be a start. Right now, nobody really knows how many chemicals are worth monitoring (see page 34). That leaves chemophobes free to assume the worst, and heightens concerns about new substances

being released with little scrutiny – concerns the industry and its regulators have signally failed to dispel.

This knowledge vacuum is slowly being filled by research programmes like Tox21 in the US, which will assess the risks of 10,000 chemicals. A similar programme on environmental effects would be welcome.

We need also to reclaim the word "chemical". Despite some heroic efforts, the word has all but become shorthand for "unwanted addition" and is used pejoratively so often that it is almost toxic itself. That needs to change.

On the whole, synthetic chemicals have a good story to tell. But until somebody takes responsibility for telling it, dihydrogen monoxide will keep frightening the unwary with depressing regularity. ■

Welcome to The Anti-Zoo



AH, THE glories of the animal kingdom. Think of antelopes trotting gracefully across the wide expanses of the African savannah, or fish darting around the technicolour paradise of a coral reef.

Or don't. Forget these glossy supermodels of nature for the moment and spend some time getting to know the natural world's oddest residents – the kind you won't see on seasonal TV.

New Scientist's The Anti-Zoo presents 50 of the strangest and

scariest animals known to science: from the hardest bat in the world to a mouse that howls at the moon, a fly that headbutts through rock and a toad with a deadly moustache.

The animal kingdom's glory is its variety. Discover it today in The Anti-Zoo, available via the *New Scientist* app and in newsagents. To find out more visit: newscientist.com/antizoo



Spotting trouble

Trafficking rife online

GOING, going, gone! Adverts on Russian websites offering endangered animals, including 54 tigers and 13 orang-utans, are among almost 9500 online ads found in 16 countries over a six-week period earlier this year. The ads promoted more than 33,000 animal products, and 54 per cent of them were for live animals.

"If we could find that in just six weeks, you have to have serious concerns about what's going on constantly," says Tania McCrea-Steele of the International Fund for Animal Welfare group, and lead investigator of the study released on 25 November.

More than half the total adverts – 56 per cent – were from China, which also dominates ivory sales, with 1662 ads for ivory or suspected ivory.

Chinese sites included 164 rhino

horn ads, even as the South African government published figures this week showing that rhino poaching has reached record levels, with 1020 rhinos poached so far this year, 16 more already than the previous record toll of 1004 in 2013.

McCrea-Steele says that some trade in endangered and live species and their products is allowed through the Convention on International Trade in Endangered Species, but cautions that it is impossible to tell which adverts are legal. She applauded major web companies including eBay and the Chinese giants Alibaba and Taobao for doing what they could to ban illegal wildlife adverts. But she says that traders are now switching to social media, which is harder to police.

Hunt the boson

WHY build your own particle accelerator when you can borrow the Large Hadron Collider? CERN has started putting data from its experiments online for anyone to use.

"The CERN portal lets you visualise the paths of particles, or you can work on the data directly"

"It's very important that we keep this data open and usable," says Kati Lassila-Perini of the CMS experiment, which has uploaded 27 terabytes of data to the CERN Open Data Portal. A web interface lets you visualise the paths of particles created by collisions, or you can work directly on the data for more in-depth analysis.

Other LHC experiments have uploaded smaller data sets to let budding particle physicists try their hands at massive-scale physics. The data could also be turned into art or music, or used for educational purposes.

Physicists might search through the data and make

discoveries, but most people with the necessary skills already work with similar experiments, says Lassila-Perini. "There are not so many spare physicists around."

CERN plans to keep uploading data each year, but only after their researchers have finished with it. So far, only data sets from 2010 have been released – not enough for you to rediscover the Higgs boson, which was found in 2012. "There are certainly some Higgs events in the data, but they are so few that you can't find them," Lassila-Perini says. "It's a needle in a haystack."

Internet powers

THE murder of British soldier Lee Rigby might have been prevented, had security services known of a graphic message sent by Michael Adebawale. So says a report by the UK Intelligence and Security Committee of Parliament, which blamed an unnamed internet firm for failing to pass on the message.

Privacy advocates were not impressed. "Internet companies cannot and must not become an arm of the surveillance state," said Jim Illock of Open Rights Group.

The report comes as UK home

secretary Theresa May is about to detail a new bill that will force internet service providers to retain the IP addresses of their customers. IP addresses register a device on the internet and often change, making it difficult to identify which device had which address at a certain time.

But they only identify devices directly connected to the internet, such as home routers, not specific computers or phones, meaning they don't identify individuals. "It is unclear how they are going to address that issue," says Emma Carr of Big Brother Watch.



Snow way out

Snowmageddon

IT'S been the warmest year on record globally. But tell that to residents of Buffalo, New York, who saw about 2 metres of snow last week as freezing temperatures hit much of the country. As *New Scientist* went to press, people were bracing themselves for possible floods from melting snow – and more snowfall was forecast for Thanksgiving. So what caused this unseasonal weather?

Cold air is usually trapped in the Arctic by the winds that circle the pole. But kinks in the polar jet stream winds caused by ex-super typhoon Nuri, which moved north across the Pacific, allowed freezing polar air to spill as far south as Texas. This caused temperatures to plummet for several days. Winds blowing across Lake Erie picked up moisture and dumped huge amounts of snow in Buffalo, in a "lake effect".

Global warming is making the atmosphere more moist and may be weakening the jet stream, so strangely it may be contributing to more snowmageddon events.

Ebola screening

JUST over 1000 travellers have been screened for Ebola on entry to the UK in the past month, *New Scientist* has learned.

Public Health England (PHE) began screening at Heathrow and Gatwick airports and the St Pancras Eurostar terminal on 14 October and later added Birmingham and Manchester airports. Staff check passengers that started out in Liberia, Sierra Leone and Guinea, the countries affected by Ebola.

A freedom-of-information request to PHE revealed that 1004 passengers had been screened up until 20 November. PHE declined to release a breakdown of the figures for each of the five ports, as the small numbers at some locations could reveal personal information, which implies they had very few qualifying incoming passengers. A recent PHE briefing says that fewer than 1000 people arrived by air from the affected countries in September, the latest figures available; around 85 per cent of those arrived at Heathrow.

The figures suggest there is little need for screening at ports, says David Mabey of the London School of Hygiene and Tropical Medicine. "It's a classic case of the government feeling the need to be seen to be doing something," he says.

Super spyware

SOMEONE'S been busy. Malware has been spying on computers in Russia, the Middle East and Europe since at least 2008, security firm Symantec said this week.

Governments, businesses and individuals have been targeted by the malware, Regin, which the firm says is one of the most sophisticated spying tools it has ever seen. They suspect it is state-sponsored.

Regin attacks a computer in multiple stages, each heavily encrypted, making it difficult to detect an attack. Symantec says it

likely took years to develop, and is similar to Stuxnet, a worm that targeted Iranian nuclear facilities in 2010 and, according to NSA whistleblower Edward Snowden, was developed by the US and Israel.

"The malware likely took years to develop and is one of the most sophisticated tools ever seen"

Symantec says it tracked versions of Regin from 2008 until 2011, when it disappeared, before re-emerging in 2013. The software can capture screenshots, recover deleted files and steal passwords.

Where are you, Philae?

#ROSETTAWATCH

TWO weeks. It has been two weeks since you landed and I still can't find you, Philae. I know it's not my fault you bounced, but I feel responsible. I'm trying to locate you - and I'm getting closer.

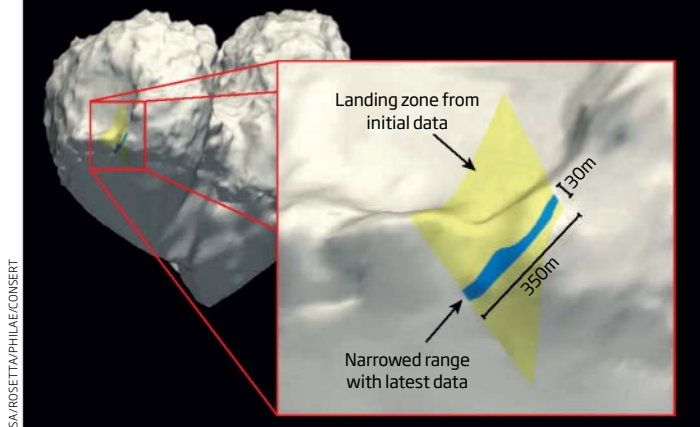
Using CONSERT, a radar instrument that links you to me - Rosetta, your mothership - I've narrowed down potential landing spots to a 350- by 30-metre strip on comet 67P's head. My human operators at the European Space Agency are now searching images to see if they can spot you.

As for your drill, it was one of the last instruments to be activated before you switched off. Mission managers know the drill operated

as expected, but because you were sitting at an angle, they don't know whether it delivered a sample to the COSAC instrument. This was designed to study molecules from the comet by heating material and measuring the resulting gas.

"I would have loved to see a clear signal from a clear sample," says COSAC lead Fred Goesmann. "My pessimistic view is we'll never know."

No more data is expected from you any time soon, and now I am ramping up my scientific mission. I'm back in a higher orbit, 30 kilometres above the comet, but I will dip to 20 kilometres on 3 December for 10 days to gather data on the increasing dust and gas spewing from 67P as it nears the sun. I'll continue looking for you, Philae.



ESA/ROSETTA/PHILAE/CONSERT

60 SECONDS

Iran nuclear hiatus

The world will have to wait a few more months to see if talking can clarify Iran's nuclear plans. The International Atomic Energy Agency has complained that Iran hasn't given them the access it promised, especially to a military installation at Parchin, the site of research allegedly aimed at bomb design.

Seals vs porpoises

An oceanic crime scene investigation led by Dutch biologists revealed the dark side of one the sea's cutest residents - seals. Evidence from DNA tests and photographs shows they may be behind the rising number of attacks on porpoises in the North Sea (*Proceedings of the Royal Society B*, DOI: 10.1098/rspb.2014.2429).

Extreme espresso

Italy's first female astronaut arrived at the International Space Station yesterday bearing gifts. The team can now enjoy Italian espresso thanks to a souped-up coffee machine that shoots hot, pressurised water through a coffee capsule into a pouch, to be drunk through a straw.

Calories counted

The US Food and Drug Administration is encouraging the country to become a nation of calorie counters by ruling that fast food chains must include their food's calorie content on their menus. The rules also apply to alcoholic drinks, and to food sold at theme parks and cinemas.

Kindly remove me

Asking to be taken off a mailing list is something we have all done, but maybe not as many times as Peter Vamplew at Federation University in Victoria, Australia. After previous attempts failed, he submitted a paper consisting of nothing but an expletive-ridden removal request to the *Journal of Advanced Computer Science*. To his surprise, the journal accepted his paper, saying it had been through rigorous, anonymous peer review and charged him \$150.

Plan B for climate change

The first geoengineering experiments could be just two years away

Andy Coghlan

IF WE can't reduce emissions enough, what else can cool the planet? We need to find out if geoengineering works, and soon, say a group of atmospheric scientists.

Engineering the planet's weather and climate is a highly controversial idea. That's why we need experiments, the group say, and they want the first to start in two years' time. The frontrunners are schemes to alter the atmosphere to reflect more of the sun's rays back into space, or to change clouds so that they let more of Earth's heat out instead of trapping it (see diagrams, below).

Last week, the group published a "road map" of proposals for how real-world experiments might be carried out (*Philosophical Transactions of the Royal Society A*, doi.org/xb9).

One would explore the effects of injecting aerosols of sea salt into marine clouds. The aim is to increase the water droplet content of the clouds, making them reflect more sunlight – so called marine cloud brightening.

The second, and most detailed, devised by John Dykema of

Harvard University, would explore the effects of injecting sulphur-containing substances at an altitude of 20 kilometres – the lower reaches of the boundary with outer space (*Philosophical Transactions of the Royal Society A*, doi.org/xb8).

The aim of the so-called stratospheric controlled perturbation experiment, or

"Modelling is critical, but the only way to understand the intricate chemistry is in the atmosphere"

SCoPEX, is to see if sulphate ions would undermine measures to rebuild the ozone layer. The fear is that such substances might set off chemical reactions that deplete the ozone.

The third experiment would explore the potential for making cirrus clouds in the upper atmosphere more porous to radiation bouncing back into space from Earth. Water vapour in the clouds behaves like a greenhouse gas, trapping heat almost as efficiently as carbon dioxide. By seeding them with substances like bismuth tri-iodide, which cause water to form into ice particles, the hope

is to reduce the water vapour and allow more radiation to escape.

Geoengineering to cool the planet by deliberately altering Earth's atmosphere is highly controversial, with sceptics fearing it will fail and mess up the climate even more. Altering cloud cover, for example, could change rainfall patterns and increase droughts and floods unpredictably. Opponents also fear that if we rely on geoengineering solutions, people will no longer strive towards the main goal of dramatically reducing our reliance on the fossil fuels that are inexorably heating up the planet.

Nevertheless, some ideas deserve further exploration, say proponents. The road map, conceived at a Harvard workshop in March, is "a big move forward", says lead author David Keith, who is also at Harvard.

So far, all geoengineering work has been in the lab or based on computer models. "Modelling and lab experiments are critical," says Dykema. "But to understand the intricate chemistry people are concerned about, the only way to find out is in the atmosphere, where you have the right flux of solar radiation, the right mix of chemical species and the real

dynamics of aerosol particle interactions in gas, liquid and solid phases."

"The proposed experiments are quite small scale, and the environmental consequences are likely to be negligible compared with a lot of human activity we already take for granted," says co-author Doug MacMartin of the California Institute of Technology in Pasadena.

Dykema's experiment, for example, involves releasing just a kilogram of sulphur, the same amount as emitted in just 1 minute by a standard commercial jet.

However, a major UK project to investigate geoengineering, called the Integrated Assessment of Geoengineering Proposals, is more cautious and pessimistic about solar radiation management.

Scaling up

For example, researchers using computer simulations have found that attempts to reduce solar radiation in the Arctic to stop sea ice from retreating are infeasible. "We found that the scale of deployment in both time and space would have to be huge before current observing systems could detect any effect," says principal investigator Piers Forster of the University of Leeds.

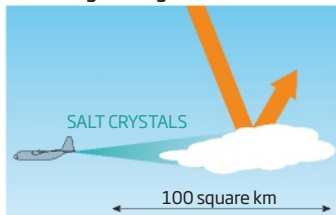
And he is sceptical of small-scale tests. "We've emitted 500 billion tonnes of carbon dioxide and we only recently have any certainty this is affecting our climate, so limited field tests would tell you next to nothing about the climate effects of solar geoengineering."

The would-be experimenters argue that, if anything, reliance on modelling increases their case to pursue more real-world data, to make the models more accurate.

Rebuffing radiation

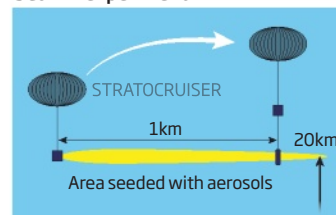
Three experiments aim to test the impact of geoengineering on solar radiation

Cloud brightening



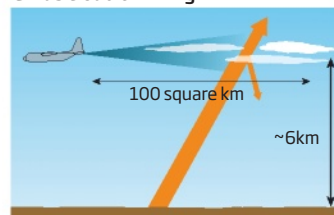
Spraying salt should increase water droplet formation, making clouds more reflective

SCoPEX experiment



The StratoCruiser balloon will disperse aerosols into the ozone layer then manoeuvre above and collect data for 3 days

Cirrus cloud thinning



Cirrus clouds sprayed with bismuth tri-iodide become more transparent, allowing reflected radiation to escape

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JUSTIN GUARIGLIA/REDFUX/VEVINE

Laboratory in the sky?

Models are potentially compromised by having too little real-world data to work with, they say.

“There are many aspects of climate interactions, especially those that affect clouds, that are poorly understood because the range of scales, from nanometres to kilometres, can’t be accurately included in global models,” says

“Experiments would give invaluable insights, even if geoengineering ultimately proved to be impractical”

Lynn Russell of the Scripps Institution of Oceanography in San Diego, California, a member of the experimentation group.

Trials would provide invaluable insights for mainstream climate research, she says, even if geoengineering ultimately proves to be impractical. Observations from such experiments would also allow us to understand cloud processes better and lead to improvement in climate models more generally, she says.

“My preference is for experiments that have broad utility, both for understanding proposed solar geoengineering schemes and improving our understanding of the natural climate system,” says Ken Caldeira of the Carnegie Institution for Science in Stanford, California.

Keith says the earliest the SCoPEX experiment could get going would be in two years’ time. In the meantime, the researchers are hoping to secure \$10 million in funding from the US government.

They also call for the formation of national regulatory bodies to independently assess the merits of all proposed experiments and give official permission to conduct them. Such approval is imperative to retain public trust, they say. “We believe that external governance is critical,” says Dykema. “But at present, there’s no one to apply to, to do the experiments.” ■

INSIGHT Benefits of immigration

Immigrants aid the economy, stupid

Debora MacKenzie

LAST week, US president Barack Obama announced an executive action offering temporary legal status to some 5 million undocumented immigrants resident in the US. His political opponents vowed to oppose the measure, saying it only rewards illegal behaviour.

They are not alone in seeing immigration as a problem. British voters have just handed a second parliamentary seat to the UK Independence Party, which pledges to crack down on immigration.

Yet, says Ian Goldin of the University of Oxford, research consistently finds that migrants boost the prosperity of their host countries. A study of the UK published on 4 November found that between 1995 and 2011, migrants from other European Union countries contributed more in taxes than they received in government benefits.

Nor is this the only positive effect. It has been common knowledge for years that immigrant workers boost wages in host countries. Using a mathematical model of the global

economy, the World Bank said in a 2006 report that if 14.2 million workers moved from poor to rich countries between 2001 and 2025, raising the rich countries' labour force by 3 per cent, the world's yearly wages would grow by \$772 billion by 2025.

This is a net gain of wealth for the global economy, created by giving migrants more capital and technology

to work with than they would have had at home. And such wage gains feed back into global prosperity more readily than other kinds of economic boosts, such as profits, because wage-earners use the money to buy more goods and services – precisely the economic stimulus governments have been trying to bring about since the crisis of 2008.

Analysis conducted by Giovanni Peri of the University of California, Davis, cites economic data demonstrating that immigrants, even poorly educated ones, help economic growth. This is because businesses absorb more labour, creating new jobs for natives – often better ones as they capitalise on

their existing educational and language advantage.

In February, Peri was co-author on the first study to use mathematical models to compare the effect of giving undocumented migrants legal status instead of deporting them. When the model was fed data from the US and Mexico, it found that more deportation resulted in fewer jobs for native-born US citizens by preventing migrants from stimulating job creation in US firms. Legalising these undocumented people boosts the economy and creates more jobs for migrants and locals alike.

Where does this leave the argument that there aren't enough jobs to go round? In May, a report by the UN's International Labour Organization decried the notion that migrants are part of the problem. "Set against this are the empirically grounded assessments of the actual economic benefits of migration and the potential benefits of relaxation of limitations on it," the report states.

Goldin attributes the misconception to the perceived short-term downsides of migrants, whereas the benefits are long-term and diffuse.

He says the answer is for governments to manage migration better by ensuring that migrants are documented, paying taxes and not competing unfairly with natives on wages and hours. That is what Obama's measure aims to do. ■



We can work it out

DNA survives round trip to space on rocket

NO WONDER life is crammed into every niche on the planet. DNA can survive blasting into space and back on the outside of a rocket.

Cora Thiel at the University of Zurich in Switzerland and her colleagues mixed small loops of DNA, known as plasmids, with a liquid solution and painted it on the outside of a rocket. It flew for 13 minutes,

reaching a height of 270 kilometres before returning to Earth.

Although atmospheric friction heated the DNA to more than 1000°C during re-entry to the atmosphere, Thiel recovered molecules from many different points on the rocket. The highest level of survival was seen inside the grooves of screw heads, where 53 per cent of plasmids made it.

The DNA of the plasmids encoded proteins for antibiotic resistance and fluorescence. When the team implanted the plasmids into *E. coli* and mouse cells, 35 per cent gave the cells these properties, suggesting the DNA

was fully functional (*PLoS One*, DOI: 10.1371/journal.pone.0112979).

The result is exciting for fans of panspermia, the idea that life on Earth was seeded by microbes from space – although it is unclear whether DNA would survive such long journeys.

But it could also pose a problem for finding alien life. When space agencies send robot explorers to other planets, they give them a deep

"The result is exciting for fans of the idea that life on Earth was seeded by microbes from space"

clean to remove all Earthly signs of life. The idea is to avoid contaminating another world, which would make it more difficult to detect genuine aliens. Thiel says her work suggests agencies should coat their robots with artificial DNA before cleaning, to confirm it has all been removed.

"This is an interesting and provocative study," says Christopher Carr at the Massachusetts Institute of Technology. Unprotected DNA in space would probably be destroyed by UV radiation, he says, but it is worth re-examining our methods of sterilising spacecraft. Jacob Aron ■



REUTERS

Flooding is just the start

El Niño leaves indelible mark on children's height

FLOODS in Peru from a severe El Niño event 17 years ago have stunted the growth of children born around that time by several centimetres.

"The children's height was permanently marked just like tree rings indicate natural disasters," says William Checkley of Johns Hopkins University in Baltimore, Maryland.

The floods destroyed crops and roads, so the shortfall in growth probably occurred as a result of malnutrition caused by food shortages, diarrhoea due to dirty drinking water, and a lack of access to healthcare, says Checkley.

The El Niño Southern Oscillation is a cyclical weather event that happens every two to seven years, when warming at the surface of the Pacific Ocean brings extra rainfall to the Americas for an extended period. It also causes drought in Australia and affects many other countries.

The El Niño that spanned 1997 and 1998 was especially severe, causing 16 times as much rain as usual in a coastal region of Peru called Tumbes, in the north-west of the country. The resulting floods cut off access to roads, isolating some rural villages for months.

In 2008 and 2009, Checkley's team visited 59 villages in the area and measured the heights and weights of more than 2000 children aged between 7 and 17. The team used historical satellite data and weather records to work out the probability that the family home had been hit by the floods.

Before the El Niño, children in that region had been gradually gaining height as a growing economy made more food available and public health improved. Each year, 10-year-old children, for instance, were on average 0.6 centimetres taller than children of the same age the year before.

But after 1997 that trend went into reverse. Children born during the El Niño period were on average 0.3 cm shorter than they would have been if the gains in height had continued.

More dramatically, those from the villages most likely to have been affected by floods were 4 cm shorter. "The event wreaked havoc in the area," says Checkley. The flooding caused yields of crops such as bananas and rice to plummet and probably caused the spread of diseases such as diarrhoea and malaria (*Climate Change Responses*, doi.org/xcd).

The effect on height persisted for children born at least three years after the El Niño. Checkley's team also found that children born after the El Niño had reduced muscle mass, which he says would affect their capacity for physical work later on, important in an agricultural and fishing community such as theirs. Other studies have found that stunted growth in childhood can have lasting effects on physical and mental health, including raising the risk of chronic conditions such as heart disease.

Checkley adds that the findings emphasise the need to warn developing countries when a severe El Niño is likely, so they can improve their flood defences and target aid to affected villages.

"The children's height was permanently stunted just like tree rings indicate natural disasters"

Adam Scaife of the UK Met Office says El Niño forecasting is generally quite accurate. It is possible to predict an event several months in advance and give an idea of its intensity, although localised predictions cannot be made. However, Armin Bunde of the University of Giessen in Germany points out that earlier this year he and other forecasters predicted a severe El Niño for 2014, which has yet to materialise. Clare Wilson ■

Dogs really do understand what you say

YOU'RE just so right-side. The left hemisphere of our brains seems to tune into the phonemes in speech that combine to form words, and the right hemisphere focuses on the rhythm and intonation of words, which can carry emotional information. Animals may do the same when processing sounds of their own species, and perhaps even when hearing humans speak.

To test whether domestic dogs have learned to process human speech as we do, Victoria Ratcliffe and David Reby at the University of Sussex in Falmer, UK, placed 25 dogs between two speakers. They played them snippets of speech, such as the command "come on then" (*Current Biology*, DOI: 10.1016/j.cub.2014.10.030). The assumption, based on previous research, was that an animal primarily using the left hemisphere to process a sound will turn its head to the right, and vice versa.

When a command was delivered in a flat emotionless tone, 80 per cent of the dogs turned their heads to the right, suggesting they were concentrating on the words, not the emotion. If the commands were said in an emotional tone but some consonants were removed to make the words unintelligible, most of the dogs turned to the left. This suggests that dogs, like us, process different components of human speech in different parts of the brain.

Ratcliffe and Reby's work suggests that dogs have learned to recognise a handful of human words that carry meaning. So a dog really does listen to its master's voice.

"It would be extremely exciting to see the neural background of these orienting asymmetries," says Attila Andics of the Eötvös Loránd University in Budapest, Hungary, who is running functional MRI brain experiments in dogs to probe this further. Colin Barras ■

Ice, Antarctic ice baby, and lots of it

Michael Slezak

THE plot thickens, or should it be the ice? The most detailed and comprehensive 3D map so far of Antarctica's winter sea ice shows that big parts of it are much thicker and more smashed-up than we thought, in fact, three times as thick in some areas. Data from this map may help us fill in some of the gaps in our global climate models, such as the amount of heat exchanged between the ocean and atmosphere.

The growth of Antarctic sea ice, which reached an all-time high this year, is one of the biggest geophysical changes that happen on Earth each year.

"It expands from about 4 to 19 or 20 million square kilometres each year. That's more than twice the area of Australia," says Rob Massom at the Australian Antarctic Division in Hobart. "And of course this has an immense effect on the ocean surface." Ice reflects more sunlight than sea and so it affects the global energy balance, for example.

Exactly how that winter ice forms, how thick it gets and by

what mechanisms, is a bit of a mystery, leaving gaps in our climate models.

Earlier maps showing more winter Antarctic sea ice in recent years are based on 2D satellite

images. But the trouble with such data is that "we don't get thickness and so therefore we don't get total change in sea ice volume", says Guy Williams at the University of Tasmania also in Hobart.

Enter a robot submarine made at the Woods Hole Oceanographic Institution in Massachusetts. Williams and colleagues used the sub and its sonar to map three areas from different sides of Antarctica, which make up an area

equivalent to twice that of the UK.

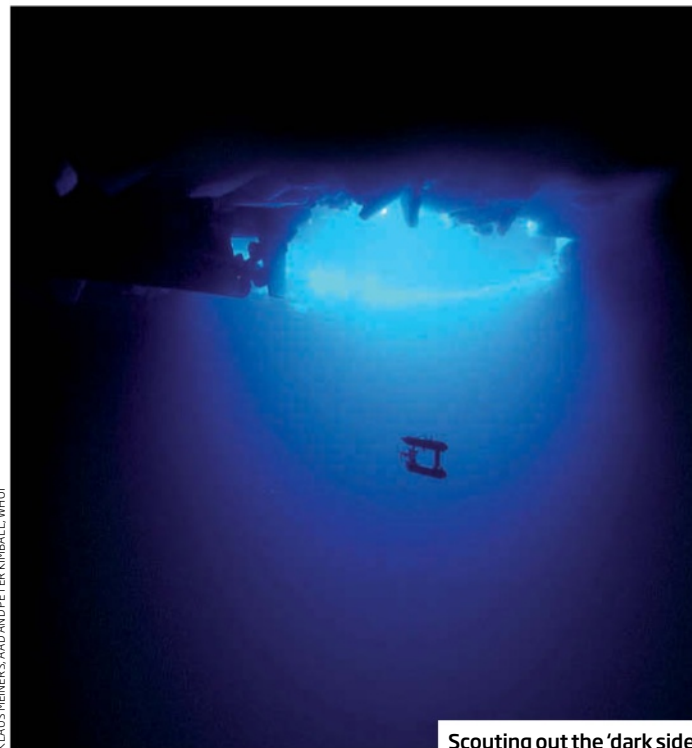
"We were surprised by what we saw," says Williams. Previous estimates based on a number of very limited methods like ship inspection and drilling suggested that only 20 per cent of the winter sea ice was thicker than 1 metre. This study found that 90 per cent of it is more than 1 metre thick, and indeed, 40 per cent is thicker than 3 metres.

The data also hints at how the ice might form, which will be crucial for building future models (*Nature Geoscience*, doi.org/xcg). If ice were left to form on still water, it would grow to about 1 metre, says Williams. Once it gets that thick, the water underneath is insulated from the air and doesn't easily freeze.

But the Antarctic sea ice is being buffeted by strong winds, which are being made even stronger by global warming. So it's getting broken up and pushed up on top of itself, making room for more ice to form.

"We found that 50 per cent of the area was deformed and that was contributing to over three-quarters of the volume," says Williams.

"It's extraordinarily significant work," says Massom. "These autonomous underwater vehicles, they're giving an unprecedented view. It's almost like looking at the dark side of the moon in terms of sea ice." ■



KLAUS MEINERS AND PETER KIMBALL/WHOI

Scouting out the 'dark side'

Upgrade will beat quantum search snags

THEY aren't here yet, but quantum computers are already getting a software upgrade. A new search algorithm to run on these machines sidesteps some of the original's pitfalls.

Computers powered by the weird rules of quantum mechanics should be able to solve certain problems much faster than ordinary PCs. One example is searching through

an unsorted database. To find all the emails you've received from your friend John, say, classical algorithms would take a time related to your total number of messages divided by the number John sent. But a quantum algorithm should be quicker, taking the square root of this time.

It's all to do with the way quantum mechanics treats particles as waves: the database you're sifting through can be described by a complicated wave equation. The search algorithm changes the size of different parts of the wave, and, once the search is complete, the results correspond to

the peaks of the wave. There's just one problem: you have to know how many results - or emails from John - you are looking for, or the algorithm can overshoot and start shrinking relevant peaks, rejecting correct answers.

Now, Theodore Yoder at the Massachusetts Institute of Technology and his colleagues have given the algorithm an upgrade

"Their algorithm can hone in on specific answers, not knowing in advance how many there are"

(*Physical Review Letters*, doi.org/w9h). Their version allows the wave function to include a type of number called a complex number. This lets it hone in on specific answers without knowing in advance how many there are. This upgraded search may be a little trickier to run, Yoder admits: "You will have to have better control of your quantum computer."

That doesn't faze Mark Tame at the University of KwaZulu-Natal in South Africa: "The additional quantum circuitry that enables this new method doesn't seem to be too challenging." Jacob Aron ■

A COLLECTION OF GREATS

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FIVE BOOKS THAT CHANGED THE WORLD

Books that change the world are rare. But one is undoubtedly *On the Origin of Species* by Charles Darwin. It has been on my shelf for decades, and, I'm ashamed to say, I have never read it. Until now.

Imagine looking out at the natural world and, in the midst of all the abundance and bewildering complexity, spotting the unifying principle that created it all. That's what Darwin did. Just as humans, by selecting individual creatures to breed, can artificially change species, Darwin showed that nature, by selecting creatures that survive to reproduce in the struggle for resources, achieves something similar. Darwin did not know what created the variety of forms – the raw material of natural selection – nor the mechanism of inheritance. That involved deoxyribonucleic acid, or DNA.

James Watson tells the story of the discovery of the structure of DNA and its key role as a store of genetic information in *The Double Helix*. Unlike Darwin's tome, it has not lain on my shelf unread for decades. That is because it is a rip-roaring read. Watson, a brash, cocky young American, hits it off at Cambridge with ex-physicist Francis Crick and, like a Batman and Robin of biology, they dash about the country, biff-boffing the competition for six.

The other players in the drama did not see it the same way, particularly Rosalind Franklin, who, had she not died at 37, might have shared Watson and Crick's Nobel Prize. Watson is appallingly bad to her but, in an epilogue so poignant it brought tears to my eyes, pays tribute to her and apologises for not realising the difficulty she faced as a woman in a male scientific world.

Another larger-than-life character was Richard Feynman. Not only did he work on the atomic bomb and share the Nobel Prize for the theory of quantum electrodynamics, he played in a Rio samba band, wrote papers in a Pasadena topless bar and played the bongos. It was his bongo-playing partner, Ralph Leighton, who recorded Feynman's colourful anecdotes in *'Surely You're Joking, Mr Feynman!'*

With his inimitable Brooklyn cab-driver delivery, Feynman tells how he watched the Trinity atomic bomb test without dark glasses; how he broke into the filing cabinets at Los Alamos, which contained



the most valuable secrets in the world; and how calculations – done for fun – of a wobbling plate in Cornell's cafeteria led to a description of a spinning electron which became a key part of his Nobel work.

I was incredibly lucky to be taught by Feynman at Caltech. He even wrote to my mother, telling her that love not physics is the most important thing. It is a story that, to my amazement, science writer Simon Singh recounted at his wedding. I mention this to provide a link to Singh's book and to be up-front about my connection. Even if I were not Singh's friend, however, I would still say that *Fermat's Last Theorem* is a wonderful read.

The 17th-century French mathematician Pierre de Fermat claimed there are no positive integers x, y, z for which $x^n + y^n = z^n$ for $n > 2$. He had a wonderful proof, he wrote, but no room to squeeze it in his margin! For 350 years, mathematicians sought the answer. Then Andrew Wiles announced he had found one, only to discover – horror of horrors – he had erred. It took a nightmare year to fix his proof.

Having begun with a great theory – evolution by natural selection – it seems fitting to finish with another – relativity. Whereas Darwin waited decades to write *On the Origin of Species*, Albert Einstein wrote a popular account within years of publishing the general theory of relativity in 1915.

Relativity is extraordinary for its brevity, directness and lack of mathematical clutter. It lacks, however, many of the helpful space-time analogies concocted by later writers. Feynman's supervisor, John Wheeler, for instance, famously summarised general relativity as: 'Matter tells space-time how to curve. And curved space tells matter how to move.' Nevertheless, *Relativity*, like *On the Origin of Species*, is remarkable for being an account of one of the greatest ideas in the history of human thought – in the words of its creator.

Marcus Chown is an award-winning writer whose books include *What a Wonderful World*, *Quantum Theory Cannot Hurt You* and *We Need to Talk About Kelvin*.



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The art of baby talk

A rich tapestry of words and sounds gives your child the best start in life

Aviva Rutkin

THERE is only one real rule to conversing with a baby: talking is better than not talking. But that one rule can make a lifetime of difference.

That's the message that the US state of Georgia hopes to send with Talk With Me Baby, a public health programme devoted to the art of baby talk. Starting in January, nurses will be trained in the best way to speak to babies to help them learn language, based on what the latest neuroscience says. Then they, along with teachers and nutritionists, will model this good behaviour for the parents they meet. Georgia hopes to expose every child born in 2015 in the Atlanta area to this speaking style; by 2018, the hope is to reach all 130,000 or so newborns across the state.

Talk With Me Baby is the latest and largest attempt to provide

Reading, one of several partner organisations involved in Talk With Me Baby.

"You don't need a neuroscientist to tell you that it's better to provide more supportive parenting and stimulating experiences," says Martha Farah, a cognitive neuroscientist at the University of Pennsylvania in Philadelphia. "But neuroscience points us to specific pathways that might be good places to intervene."

Attention was first drawn to the importance of language nutrition two decades ago. Psychologists Betty Hart and Todd Risley at the

University of Kansas tracked 42 families with young children for several years, noting the number and type of words that parents spoke to their children over the course of a typical day. The data revealed an alarming trend: by the age of 3, children from affluent families had heard some 30 million more words than their impoverished counterparts.

Early language exposure has since been linked to a number of cognitive skills, including attention, memory and emotional development. For example, studies of bilingual children – who hear a greater variety of

sounds – suggest that they are better at tasks such as ignoring irrelevant information and switching between different activities. Those who hear more words early on also have larger vocabularies and better real-time word processing by the age of 2.

Grade boost

Such findings have persuaded policy-makers that more and better conversations can help kids from disadvantaged backgrounds get ahead in school and in life.

"Daily interactions help our youngest kids learn words, build

"The idea is that language is as important to the brain as food is to physical growth"

"language nutrition" to infants in the US – a rich quantity and variety of words supplied at a critical time in the brain's development. Similar initiatives have popped up in Providence, Rhode Island, where children have been wearing high-tech vests that track every word they hear, and Hollywood, where the Clinton Foundation has encouraged television shows like *Parenthood* and *Orange is the New Black* to feature scenes demonstrating good baby talk.

"The idea is that language is as important to the brain as food is to physical growth," says Arianne Weldon, director of Get Georgia



CHAD SPRINGER/PLAINPICTURE

vocabulary, and yes, develop their brains,” former US secretary of state Hillary Clinton told a conference at the New York Academy of Sciences earlier this month, where such interventions were discussed. “They lay a foundation for future success long before a child steps foot into a classroom for the first time. Sadly, however, many of our kids are not getting the support they need to grow and thrive to their fullest potential.”

This is acutely felt in Georgia, where 27 per cent of children were living in poverty in 2012 – 5 per cent higher than the national average – and more than half are eligible for free or reduced price meals at school. The specific aim of Talk With Me Baby is to boost the state’s dismal school reading levels – just a third of children are reading proficiently by the age

of 8 – but it will also be evaluated on its impact on overall well-being, reported via measures such as preschool expulsion rates.

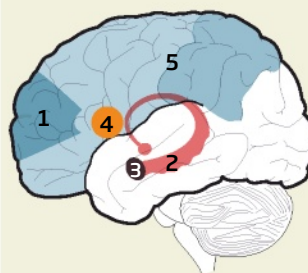
The first year of life is a particularly explosive time for neural growth. Although babies aren’t yet talking, their brains are already identifying common speech sounds by how often they appear. At this point, they can distinguish between nuances in languages as disparate as Chinese and Swedish, an ability that falls off as they age.

It’s imperative that this language exposure happens in person. In a study run by Patricia Kuhl at the University of Washington, babies from English-speaking families sat through a dozen 25-minute sessions of reading and playing in Mandarin Chinese. Some spent their time face-to-face with a native Mandarin speaker, while others watched identical sessions on DVD or listened to audio while looking at a teddy bear. The former group learned to differentiate between Mandarin syllables as well as babies raised in Taiwan but the latter two could not.

Through Talk With Me Baby, Weldon and her team intend to demonstrate effective speech to parents first-hand. One trick is to talk in parentese, the slow sing-song cadence that adults tend to slip into when speaking to children – studies suggest that infants pay more attention to it than to regular speech. Another is to talk about whatever seems to already draw the child’s attention, like a passing train or a toy, rather than try to get them to focus on something different.

The professionals will be expected to demonstrate the good speech skills as they work. A nurse teaching a new mother how to give a bath, for example, might explain the steps directly to the baby while the adult listens. The project also plans to release a smartphone app for parents that plays videos of sample baby talk

DEEP IMPACTS



The first 1000 days of life are a busy time for the growing brain. An impoverished environment can have a lasting impact.

1 The prefrontal cortex is behind much of our thinking and reasoning. Children born to parents with lower educational achievements tend to have thinner prefrontal cortices, which may explain why they are worse at filtering out distractions while they work – a skill specific to this brain region.

2 The hippocampus is responsible for learning and memory. Kids who had poor parental support in early childhood show signs of a smaller hippocampus by the time they reach school age.

3 A smaller amygdala, a structure that handles our emotions, has been associated with children from low-income homes or born to

parents with less education.

4 During our early years, different regions of our brains start to specialise in certain tasks. Word tasks are delegated to the left side of the brain, in particular to Broca’s area. But fMRI scans of 5-year-olds found that the brains of those from disadvantaged backgrounds weren’t as specialised as their high-income counterparts.

5 MRI scans of children under 5 found that those from low-income families had lower volumes of grey matter in their frontal and parietal lobes, which are associated with working memory and language, among other things.

That’s not to say that these changes can’t be overturned. The brain is most malleable in childhood, and responds well to interventions in the early years. For example, the Bucharest Early Intervention Project has followed 136 children from Romanian orphanages since 2000. Those placed in foster homes before they turned 2 showed higher brain activity across several different regions and higher scores on emotional and cognitive tests compared with those who remained in institutions.

and suggests conversation topics based on your location.

Meanwhile, other organisations are exploring what language nutrition can do for children. The Thirty Million Words initiative in Chicago teaches a 12-part language nutrition programme

“As we learn more about the brain, we’re able to be more effective in closing children’s language gap”

centred on “three Ts”: tune in, talk more and take turns. Jessica Polk, a Chicago mother of three, went through the programme several years ago. She says it helped her learn how to build conversations around what her baby was

interested in. “We realised we should tune into what they want to do and they’ll pay attention more,” she says. “I’ve told a lot of people about it.”

Thirty Million Words is now recruiting for a randomised control study. For five years, it will follow the progress of 200 Chicago families, half of whom will undergo language nutrition training, to see what kind of impact the intervention has on school readiness.

“As we learn more about the brain and how it is connected, we’re able to be more effective in trying to impact this public health issue,” says Dana Suskind, founder of Thirty Million Words. “Brains aren’t born. They’re built.” ■



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Polish 'vampires' were locals not persecuted outsiders

HOW do you spot the undead? In 17th- and 18th-century Poland, special burial rites were meant to keep vampires from rising from their graves. Now a team has been trying to figure out why these corpses were singled out as supernatural suspects.

Lesley Gregoricka at the University of South Alabama and her colleagues looked at six burials excavated in recent years in Drawsko County, Poland. Each body was staked down with sickles (pictured) or had a stone placed in or under its jaw – documented anti-vampire measures. By examining the ratios of different isotopes in the tooth

enamel, the team determined where these corpses came from (*PLoS One*, DOI: 10.1371/journal.pone.0113564).

"We were surprised to learn that the Drawsko 'vampires' were local to the area," says Gregoricka.

"We expected that these individuals were targeted for deviant burial because of their status as outsiders to the community."

Instead, the team suggests the six suspects may have been victims of the cholera epidemics that hit Eastern Europe in the 17th century. Being the first local to die from a disease outbreak could be another reason to mark someone as a vampire risk, they say. "The spread of diseases like cholera was very poorly understood in the 17th century," says Gregoricka. "So people turned to the supernatural to make sense of death and misfortune."

Plant extract boosts calorie-burning fat

EASY weight loss always comes with a catch. A plant extract has helped obese mice burn off the calories without exercise – but there are concerns over its safety.

The fight against obesity gained ground in 2009 with the news that our bodies carry deposits of brown adipose tissue – a type of fat that burns calories by turning energy into heat. Since then, researchers have been trying to

ramp up brown fat activity.

Enter berberine. A plant extract found in many Chinese herbal medicines, it has been linked to reductions in insulin resistance in animals. Guang Ning at the Shanghai Jiao Tong University School of Medicine gave it to mice every three days for a month. Scans showed that their brown fat burned more calories than that in mice not given the extract. There

were also signs that the animals' ordinary fat had begun to act like brown fat. As a result, the mice had better control over their weight (*Nature Communications*, DOI: 10.1038/ncomms6493).

It's quality research, says Henri Huttunen at the University of Helsinki in Finland. But even if the results are repeated in people, berberine may not be the answer. Work by Huttunen suggests it may have a toxic effect in the nervous system of rodents.

Earth's life-friendly orbit due to Saturn

EARTH'S comfy climate may be thanks to Saturn's good behaviour. If the ringed giant's orbit had been slightly different, Earth's own path could have been more like a comet's.

Planets in our solar system tend to have circular orbits and lie in the same plane. Elke Pilat-Lohinger at the University of Vienna, Austria, wondered if that tidiness was thanks to the combined influence of Jupiter and Saturn, the solar system's heavyweights. She used computer models to study how changing their orbits might affect Earth.

She found that moving Saturn's orbit 10 per cent closer to the sun or tilting it by 20 to 30 per cent would stretch Earth's orbit so that it would spend part of the year outside the habitable zone, where liquid water can be sustained – or boot it from the solar system entirely (*International Journal of Astrobiology*, doi.org/w9g).

Hairy kisses get spiders in the mood

IT'S a hairy affair. The males of a Costa Rican spider, *Leucauge mariana*, have evolved a trick to keep females from looking for other males to father their offspring – they tickle them with hairy mouthparts.

A team led by Anita Aisenberg from the Clemente Estable Biological Research Institute in Montevideo, Uruguay, removed the hair-like setae from spiders' mouthparts and studied what happened (*Behavioural Ecology and Sociobiology*, doi.org/w9c).

Females paired with "clean-shaven" males were more likely to stop mating and to later mate with others. Tickle appears to be a way of winning a female's favour and keeping her from finding other sires for her little ones.

Barley was key to lofty Tibetan life

THE roof of the world is not exactly where you might imagine seeing waving fields of barley. But it was this crop that led humans to colonise the Tibetan plateau 3600 years ago.

Archaeological evidence, including handprints, found at 4.2 kilometres above sea level suggests humans had an intermittent presence on the Tibetan Plateau as long as 20,000 years ago. By 5200 years ago, villages began to appear at lower altitudes, but it wasn't until 3600 years ago that humans permanently settled at heights above 2.5 kilometres.

Fa-Hu Chen of Lanzhou University in China and colleagues studied plant remains, animal bones and artefacts from 53 archaeological sites across the north-eastern part of the plateau. They found evidence of millet being farmed at lower altitudes, but by around 3600 years ago there was a shift to farming barley, which is resistant to frost (*Science*, doi.org/w9b).

Barley probably came from the Middle East, and the opening of trade routes across Asia around 4500 years ago would have helped the spread, says co-author Martin Jones of the University of Cambridge.

"It's a global phenomenon of farmers taking on exotic crops," he says. "It's an expansionist period. People were looking for options in new, extreme environments."



Galaxies are spaced like pearls on a necklace

GALAXIES like to keep their distance – 30 million light years of it, to be precise. An analysis of thousands of galaxies finds that they are strung like pearls on a necklace, even on smaller scales.

On large scales, the universe is made up of empty voids laced with narrow, winding filaments of dark matter that guide the growth of galaxies and galaxy clusters. This cosmic web holds a repeating pattern on the order of hundreds of millions of light years – but things were supposed to get messier when you zoom in.

Now, Elmo Tempel at Tartu Observatory in Estonia and his colleagues have found a small-scale pattern in cosmic structures.

The team looked at 68,373 galaxies and 35,158 groups of at least two galaxies that all lie within 1.5 million light years of a large-scale filament. They found that individual galaxies and groups tended to lie either 30 million light years from each other or, less frequently, about 18 million light years apart (*Astronomy & Astrophysics*, doi.org/w9f). "I did not expect to discover

anything like this," Tempel says.

The larger separation could be a result of how galaxies and clusters grow, says Tempel. As a galaxy forms it uses its gravity to gather matter within a certain distance – but any that's farther away is unattainable. That critical distance could be 30 million light years, Tempel says.

But Anatoly Klypin, a theorist at New Mexico State University in Las Cruces, suggests the smaller separation could be an artefact of the way Tempel and his colleagues chose the galaxies to analyse.

Tapeworm squirms across man's brain

A TAPEWORM that usually infects dogs, frogs and cats has made its home inside a man's brain.

The Chinese man was admitted to a UK hospital with headaches, seizures and an altered sense of smell. An MRI scan showed an abnormal region in the right side of his brain, but no tumour. Over four years, this region moved across the man's brain, until surgery pulled out a 1 centimetre-long ribbon-shaped worm.

Genetic sequencing identified it as *Spirometra erinaceieuropaei*, a rare tapeworm found in east Asia. Just 300 human infections have been reported since 1953, not all of them in the brain. "Humans aren't the natural host for the worm so when it enters a human, it doesn't migrate to the gut as it usually would," says Hayley Bennett at the Wellcome Trust Sanger Institute in Cambridge, UK. When the worm does get to the brain, it triggers inflammation, which causes headaches and seizures.

Its genome was 10 times larger than any tapeworm's sequenced so far, partly due to an expansion of gene families that help the parasite invade its host. This may be why it can infect many animals (*Genome Biology*, doi.org/w89).



Beer has its own anti-spill mechanism

COFFEE spills more easily than beer, and physics can explain why.

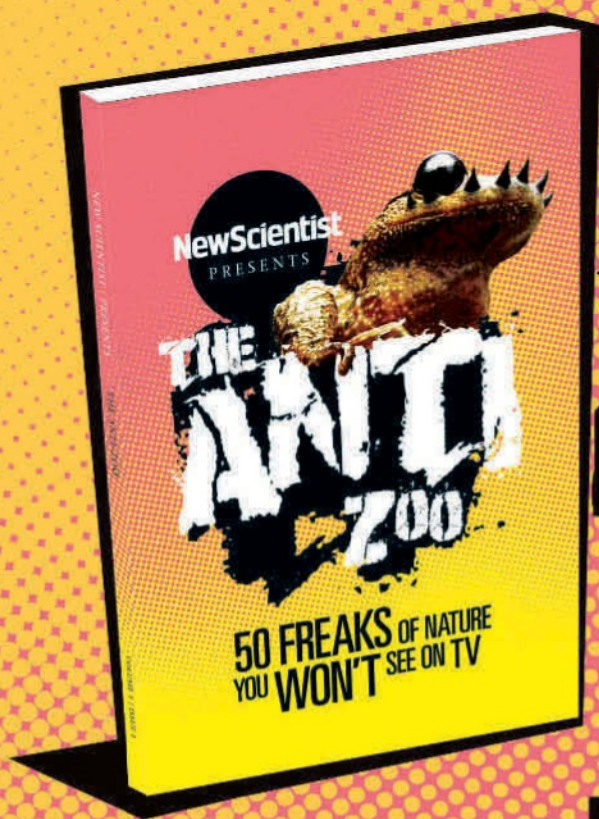
Carrying drinks from the bar, Alban Sauret at Princeton University noticed that beer rarely sloshed out of a glass, provided it wasn't full to the brim. The same was true of a latte, though less so, but not a regular coffee.

To investigate, he and his colleagues mixed water with glycerol and surfactants and blew bubbles to create a stable foam. The mix allowed them to control the size of the bubbles and the thickness of foam. The team jolted containers holding liquids covered with different foams

and filmed their sloshing motion, then analysed the video to study how the velocity of individual bubbles related to the foam's dampening abilities.

It turns out just 0.3 centimetres of foam is enough to dampen much of the sloshing motion, and 3 centimetres stops it almost completely, Sauret told the American Physical Society at a meeting in San Francisco this week.

The study started as pub talk, but may have useful applications in keeping hazardous fluids from spilling over.



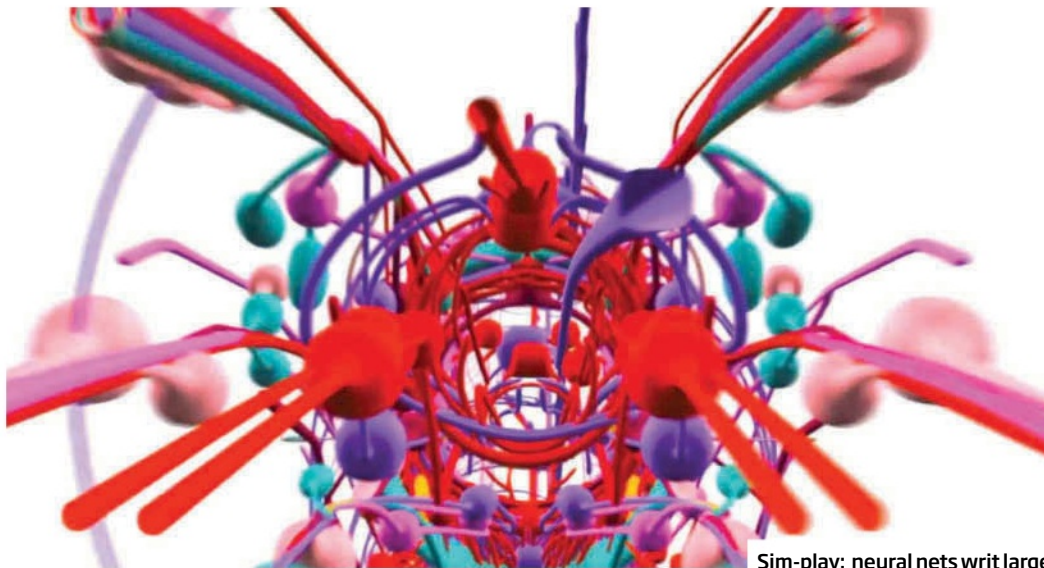
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Sim-play: neural nets writ large

Animal, digital, alive?

Next year the world's first digital animal will be created inside a computer, posing complex ethical questions

Catherine Brahic

THE Lego robot trundles forward, encounters a wall, stops, reverses. You might think there is nothing clever about that, except that this one has not been programmed to tell it when to stop and when to turn. Instead, it has an artificial brain precisely modelled on that of a nematode worm. WormBot is part of an effort to build the world's first digital animal.

The quest to create such a creature is more than just a technical challenge. It will also pose some uncomfortable questions: if a digital model is an exact replica of a living animal, is it then alive?

The bot's artificial brain has the same number of cells as a real nematode brain, and they are connected up in exactly the same way. But instead of a fluid tubular body animated by 95 muscles, WormBot has a plastic body and two wheels. It does not eat, defecate, reproduce or die. That

will be left to its future sibling, WormSim, which will be a cell-for-cell digital copy of the worm, living inside a computer.

Both projects began with the simplest, smallest brain that we know of – the one that is inside the nematode worm *Caenorhabditis elegans*. This lab workhorse was the first organism to have its genome sequenced, and the first to have its entire brain mapped. It is largely hermaphrodite, with 959 cells each of which has also been mapped. Its network of 302 neurons connect via 6393 synapses – its connectome – and link to the worm's 95 muscles at 1410 junctions.

This level of detail makes the worm an ideal candidate for a 3D avatar accurate down to the last cell. So earlier this year, independent researcher Tim Busbice launched the OpenWorm project on Kickstarter. He has already created WormSim's brain and musculature, linked them up, and is busy dropping it into

virtual water to start fine-tuning its first strokes – a nematode worm swims by undulating its 1-millimetre-long body. Sensory organs will come next. The worm should be ready for testing by next year. For an investment of \$49, Kickstarter backers will get their own WormSim to play with on their computers. All of this data will be on an open source

“WormBot moved towards the sound much as a real worm would be lured by the smells from food”

database, which has already provided the blueprint for WormBot's brain. Within five years Busbice hopes to have a bot with more complex behaviours, such as eating.

There's a long list of reasons for creating a virtual animal. “The mere act of trying to put a working model together causes us to realise what we know and what we don't know,” says John Long, a

roboticist and neuroscientist at Vassar College in New York State. Digital animals could complement and in some cases dispense with animal experiments. *C. elegans* is such a boon because it is so simple, yet 80 per cent of its genes are the same as ours. WormSim opens up the possibility of messing with a lab animal in ways that are not possible in the real thing.

Busbice started by building a neural network in which the neurons were connected to each other according to the *C. elegans* connectome. In a live animal, neurons often latch onto each other through repeated connections: so neuron A might make five synapses to neuron B, and each time A fires, all five relay the signal to B. Busbice used weightings to represent this in his neural network. Just like real neurons, those in WormBot, receive inputs from a network of “upstream” neurons and have to reach a threshold in order to fire and pass the signal on to those downstream. If that threshold isn't reached a set period of time the system resets to zero.

Instead of muscles, WormBot has two wheels controlled by a matrix of 95 cells, representing the 95 muscles of *C. elegans*. Busbice hooked up the worm's chemosensory neurons, which a real worm uses to detect smells and tastes, to a microphone that is triggered beyond a certain decibel threshold. He also connected the worm's “nose-touch” neurons to a sonar that would send a message upstream to the brain if WormBot gets within 20 centimetres of an obstacle.

When all this was assembled, Busbice flipped the switch and began whistling, softly at first then louder and louder. Once his whistles got loud enough, the wheels were set in motion and WormBot moved towards the sound much as a real worm would be lured by the smells wafting from food.

◀ When the bot came across a chair leg, its sonar picked up the obstacle, and without being programmed to do so, it stopped and reversed. “It’s only the connectome that makes it happen,” says Busbice.

“It’s very cool. I would not have guessed that this would have worked with minimal tuning,” says Murray Shanahan, a cognitive roboticist at Imperial College London.

Busbice has run rudimentary tests with his model. Previously, several teams of biologists have tweaked the brain of a real *C. elegans* by cutting specific

existing connections, or forming new ones. This is way out of reach for Busbice’s creation.

It’s not, however, out of bounds for advanced editions of WormSim or future digital animals. And that raises all sorts of difficult philosophical questions.

“It’s an emotional and disturbing question,” says Shanahan. “Suppose you did this for the mouse, and it behaved in all the same ways as a real mouse does. Insofar as you know the real mouse can suffer, you have to ask yourself whether the virtual mouse does too.”

Assuming a neural network can learn and evolve just like a real organism, Schmidhuber says he doesn’t see a big difference between the two. “To me they are life,” he says. “And as they become more and more complex you start to have ethical questions, such as should you really turn off the computer.”

For many working in artificial intelligence the ethical questions are profound but they do not apply to WormBot – it’s too basic. Nor will they apply to the more sophisticated WormSims. Embodiment is essential – connecting up a virtual animal’s brain to all of its organs and sensors, says Shanahan. He adds that we are a long way from having an embodied mouse connectome, say, let alone anything else. Not only is computing power an issue (a mouse has 22 million neurons), we also don’t yet know enough about a mouse’s physiology to accurately model each cell.

Nevertheless, says Shanahan, WormSim throws the deep existential questions of embodied connectomes into the light. “I don’t think *C. elegans* is conscious, but if we really did build this for a mouse I can’t see any reason to deny suffering and consciousness to a synthetic copy,” he says. “It’s a deep philosophical question. I can’t think of a more important question.” ■

“I can’t see any reason to deny suffering and consciousness to a synthetic copy of a mouse”

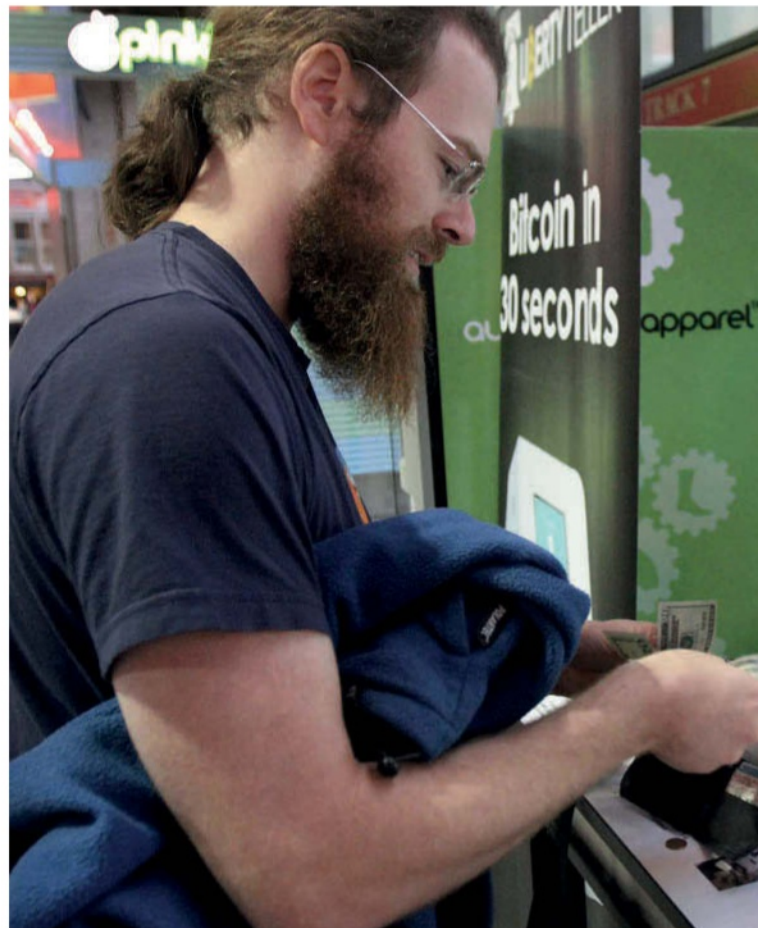
neurons to see how this would change its behaviour. Busbice says he has done identical tests in his neural network, and watched his robot’s behaviour change in the same way as the live ones did.

This does not mean WormBot’s behaviour is intelligent, says Jürgen Schmidhuber of the Dalle Molle Institute for Artificial Intelligence Research in Manno, Switzerland. Its neural network is completely fixed. Intelligent living things learn from their experiences and these memories and new bits of information are encoded in their brains by strengthening or weakening



The real worm

STEVE GCHNESSNER/SCIENCEPHOTO LIBRARY



Follow the digital money

Students are receiving \$100 of free bitcoins. **Aviva Rutkin** finds out how they plan to spend it

WHAT happens when you hand college students free cash? That’s the question behind an experiment playing out in Cambridge, Massachusetts. Starting this month, \$100 worth of bitcoins are being given to students at the Massachusetts Institute of Technology.

Bitcoin has been heralded as the future of money, an anonymous way to purchase anything from a coffee to illegal drugs. But it has struggled to make the transition to common

currency. By injecting bitcoins into a real-world community, the MIT Bitcoin Project hopes to spur acceptance of the cryptocurrency among people who might not otherwise try it.

“We’re cultivating an ecosystem,” says Dan Elitzer at MIT Sloan School of Management, who runs the project along with Jeremy Rubin and Richard Ni. “We’ve got that density and that critical mass adoption to hopefully see what’s possible once Bitcoin is more broadly accepted and broadly used.”



STEVEN SENNE/AP/PA

of bitcoins. His Fireflies app will let students request or carry out tasks for each other on campus in return for bitcoins, like picking up a meal from the cafeteria on a cold night. In August, Fireflies won the \$1500 Awesome Award from a competition hosted by the MIT Bitcoin Project.

"You can go to restaurants or buy stuff online, but in terms of physically using it, there isn't that much you can do yet," says Udotong. "We're hoping Fireflies will fill that hole."

A number of students have chosen not to spend their bitcoins, instead keeping them as an investment or selling them for regular cash. Jonathan Harvey Buschel, a first-year student studying electrical engineering, says he plans to use some of his allotted bitcoins as a means of sending money

"Increasing awareness of cryptocurrencies is a positive thing, though be aware of the risks"

to friends, as Bitcoin offers an appealing alternative to banking apps.

It remains to be seen whether the project will create a self-sustaining community around Bitcoin. Elitzer's team is collecting data from users to find out how they used their money and whether their attitudes toward the currency have changed.

"I think that increasing awareness of cryptocurrencies is a positive thing, though it's also important for people to be aware of the associated risks and regulatory issues," says John Villaseñor at the University of California, Los Angeles. For example, a crash at popular exchange site Mt Gox earlier this year cost customers millions in bitcoin. Regulations about the finer points of Bitcoin remain in a grey area, as seen in the recent legal battle over a mining tool named Tidbit.

William Luther, an economist at Kenyon College in Ohio, adds that the project may struggle to triumph over the limited opportunities to spend bitcoins and societal pressure to use more common currency. "It's not a slam dunk. You can give a student \$100 worth of Bitcoin, but you can't make them use it," he says. ■

Show me the money

To fund the project, Elitzer and his team raised more than \$500,000 in alumni donations earlier this year; about half came from Alexandar Morcos, a former student who runs a high-frequency trading firm in New York City. The first stipends started rolling out to students who had signed up two weeks ago. The students are free to do what they want with the bitcoins – so long as it's legal.

One popular way to spend the stash is on takeaway food. The Boston area boasts a number of shops that accept bitcoin, including Patty Chen's Dumpling Room and Veggie Galaxy. It also had one of the first bitcoin ATMs in the US. In addition, the MIT campus store now accepts the currency in exchange for things like textbooks and college sweatshirts.

Sam Udotong, who studies aerospace engineering, plans to launch a start-up in the next two weeks sparked by the campus's influx

ONE PER CENT



Smartwatch predicts seizures

This is not just any smartwatch – it can spot the warning signs of an epileptic seizure. Called Embrace, it measures the skin's electrical activity – a proxy for changes deep in the brain – and uses a computer model to predict if a seizure is about to occur. When Embrace detects the warning signs, it sends a message to the wearer's friends or family. Its developer, Empatica, launched a crowdfunding campaign last week and has so far raised more than \$140,000.

"The development and operation of this malware would have required a significant investment of time and resources, indicating that a nation state is responsible"

Security firm Symantec on the discovery this week of the Regin virus that has spied on governments and businesses since 2008

Your shirt knows when you're thirsty

Listen to your shirt. Smart clothing could warn its wearers when they need a drink. Xsensio, based in Switzerland, is developing textiles that look for signs of dehydration by measuring body temperature, sweat and skin conductance. Sensors also take air temperature and humidity into account. As a person becomes weary and thirsty, the shirt will send alerts reminding them to drink – useful for sporty types.

Employment tracked via tweets

Add job status to the list of things your Twitter account gives away. Alejandro Llorente at the Autonomous University of Madrid and colleagues examined 145 million tweets sent across Spain. Tweeters in regions with higher unemployment were more likely to misspell words, less likely to post in the morning and less likely to talk to people living in places with high employment levels (arxiv.org/abs/1411.3140v1). These markers could be used to understand the effect of policies on the economic status of cities, the team says.

INSIGHT Security



CHRIS TURNER/STONE/GETTY

Messages hidden from prying eyes

A little privacy, please

WhatsApp is getting encryption – and it's not alone, says **Hal Hodson**

THE internet is wising up. Companies and consumers are turning to encryption to boost levels of privacy and security on the web.

On Tuesday, WhatsApp, the world's most popular mobile chat service, announced that it has built end-to-end encryption into the latest Android version of its app. Previously, all messages sent via the app were decrypted on a server before being re-encrypted and sent to their destination. At this intermediate stage they were vulnerable to surveillance from the likes of the US National Security Agency.

Now, the billions of messages sent through the app every day make the whole journey in total privacy, readable only by the sender and the recipient.

The update is based on an encryption system designed for a messaging app called TextSecure, created by security researcher Moxie Marlinspike. Many privacy-conscious people have chosen to download TextSecure, but the WhatsApp update brings private communication to hundreds of millions without them needing to lift a finger.

It's not before time. Whether we realise it or not, we all leave trails of

personal information when using the internet – and without encryption, it could easily fall into the wrong hands. "The amount of info you are inadvertently sending in plain text would horrify most people," says Alex Halderman, a security researcher at the University of Michigan.

Another big step to improve internet security was launched on the same day as WhatsApp's update. Let's Encrypt is a non-profit certificate authority – an organisation that hands

"The amount of information you are inadvertently sending in plain text would horrify most people"

out digital certificates that verify websites are who they say they are. If you access a site that doesn't have a valid certificate, a red padlock and warning sign are displayed in your browser. Other certificate authorities make websites pay for verification, but Let's Encrypt is giving it away for free, backed by a consortium of technology companies.

Verification and encryption are most powerful when used together – encryption makes sure data can only

be seen by the sender and recipient, while verification stops the data being sent to someone fraudulently posing as the intended recipient.

Encrypted connections are great, but a whole swathe of the internet is still unprotected. That's changing too. Last week, the Internet Architecture Board recommended that every new protocol built for the web, whether designed to pull data from smart fridges or to handle payments, should use encryption by default.

Smartphone payment systems like Apple Pay and Google Wallet Credit are ahead of the times, protecting credit card numbers with encryption. These apps use cryptography to generate a unique payment token every time you use your card through them, keeping your number private.

With wide enough adoption, this would mean retailers would not have a large database of credit card numbers that could be stolen, as they were recently at Target and Home Depot.

Halderman says there's a clear trend. "The technology is evolving so that encryption is becoming much easier to use," he says. "More and more the typical user is recognising the importance of privacy and security." ■

Drones do awkward dance to avoid crashing

NO, I insist, after you. That awkward moment in the street is something drones can now share with us, thanks to an update to their navigation systems.

Parker Conroy and his team at the University of Utah in Salt Lake City have designed a collision-avoidance system that allows quadcopter drones to "see" each other and take steps to avoid crashing in mid-air. Cameras detect patterns on an oncoming quadcopter and the size of these in pixels indicates the distance between them. The rate of change of this value indicates relative velocity. An off-board computer then calculates the area within which a collision could occur and tells the drone to take evasive action (arxiv.org/abs/1411.3794).

Sometimes, however, the drones misjudge the trajectory of their partner and dodge in the same direction. They automatically correct their paths, but for a moment they are engaged in a human-like "reciprocal dance".

"It's not often you see robots dancing on their own," says Conroy, who now works for robot manufacturer Adept Technology. Mirko Kovac at Imperial College London's new centre for flying robots says it's vital that drones in the future have these kind of built-in "instincts". Chris Baraniuk ■



TOMASZ ZADVA/ALAMY



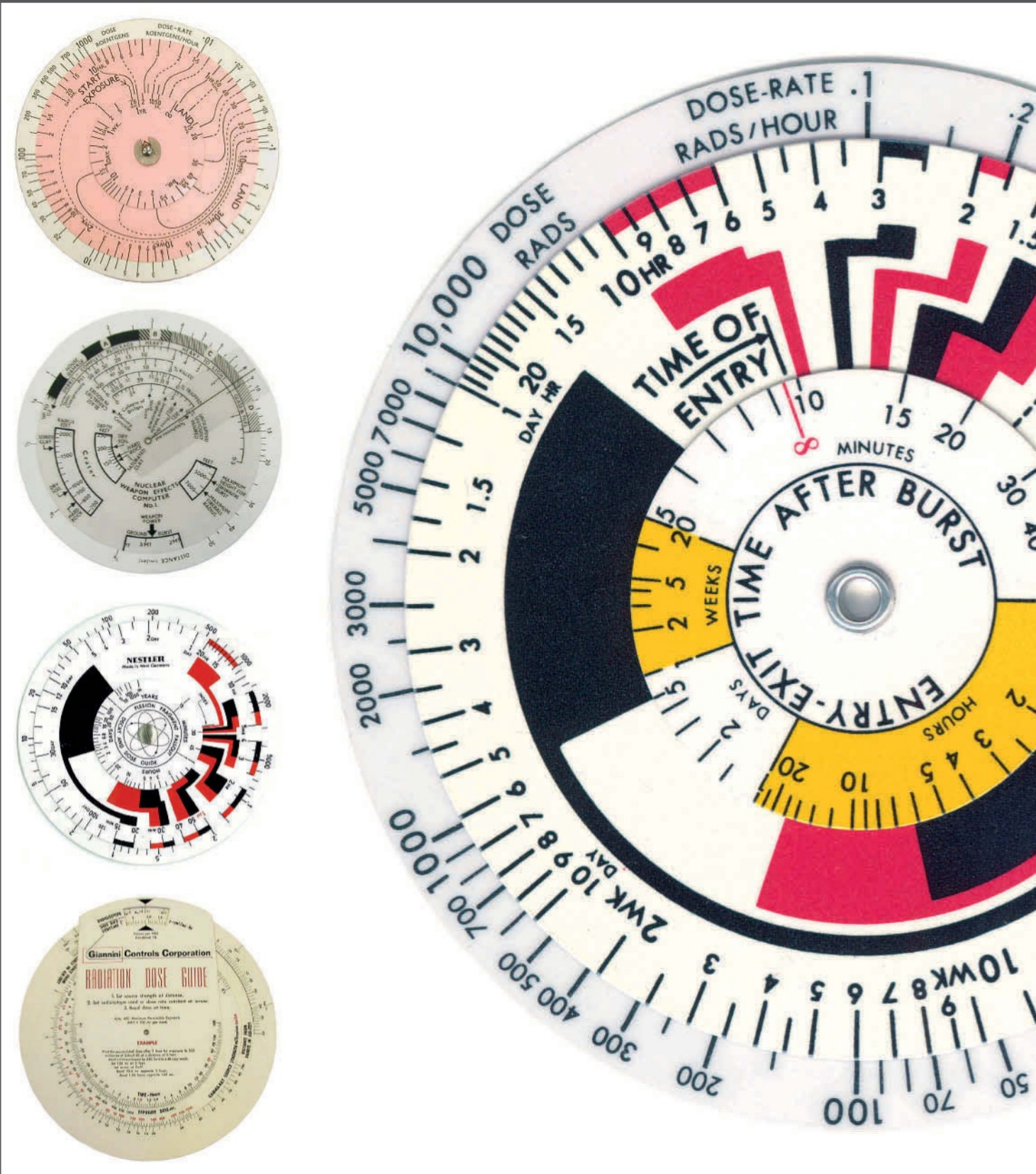
The evolution of a genius ape

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NewScientist





Strange slide rule love

"WHAT type of people are fond of slide rules?" asks Paul Frame, newly retired from Oak Ridge Associated Universities, Tennessee. "Old folks. I didn't have an electronic calculator until I was a graduate student."

Until the mid-1970s, Frame did most of his calculations with a slide rule. "Engineering students on campus were easy to spot. They had a big leather case for their slide rule, hanging from their belt like a sword scabbard."

Younger generations simply have no clue what slide rules were used for. "The fact that many people don't know what they are adds to their perceived value to us old folks," says Frame.

At Oak Ridge, Frame has put together a collection of circular slide rules designed for radiologists. Some were for calculating X-ray exposure times, shielding requirements and radioisotope decay; others for working out the explosive yield of nuclear weapons.

The ones that most fascinate people, says Frame, are those with cold war associations. "These are the slide rules that can help military personnel and civilians navigate the radioactive world that will exist after a nuclear detonation has occurred."

Nicknamed cold war slide rules, they became famous when Peter Sellers used one in *Dr Strangelove*. "I have seen the movie maybe 10 times," says Frame. "He is calculating how long he and the other military bigwigs and politicians will have to reside underground after the Soviet Union's doomsday device goes off." Rowan Hooper

Photographer

Oak Ridge Associated Universities

Japan's nuclear dilemma

The country may soon restart its nuclear power stations. But have the limits of safety assurances really sunk in, wonders **Robert Geller**

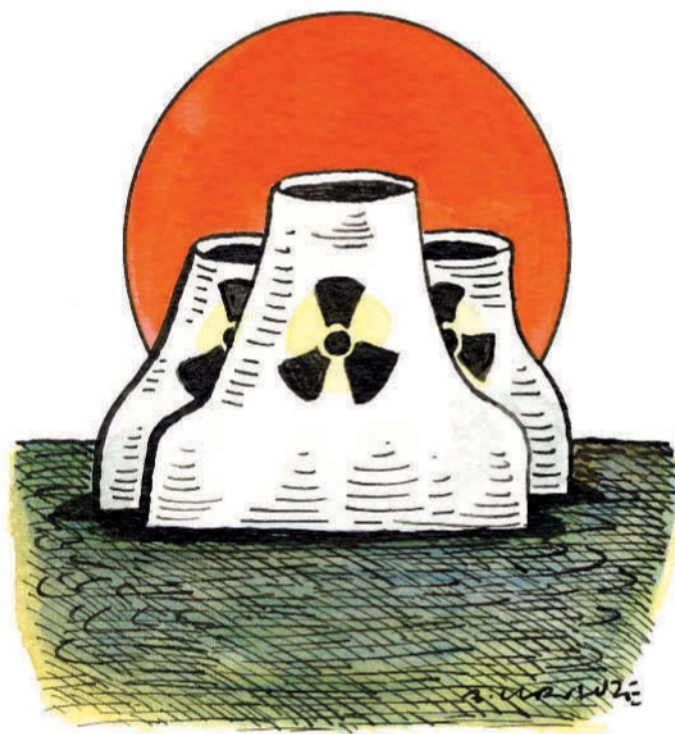
NEARLY four years after the devastating Tohoku earthquake and tsunami that led to a severe nuclear accident at the Fukushima Daiichi power station, Japan stands on the brink of a major decision: whether to restart its nuclear power plants.

Two key questions come to the fore in such an earthquake-prone region: which hazards can nuclear plants withstand, and can society as a whole live with the risks posed by hazards that plants cannot withstand? The latter is an inherently political question.

Japan had 54 commercial reactors in operation before the disaster. Four of the six reactors at Fukushima Daiichi were damaged beyond repair in 2011. The other two are to be decommissioned.

The remaining 48 reactors were taken out of service after the earthquake. Two reactors at the Ohi plant, on the Sea of Japan coast of Honshu island, were restarted in July 2012 under the Democratic Party of Japan government, but amid legal wrangling, they have been off-line again since September 2013.

Fukushima underscored the inadequacies in the existing oversight of the nuclear industry, and the DPJ government established a new Nuclear Regulation Authority three months before it fell from power in the December 2012 elections. The NRA's checks are ongoing, but it is expected that reactors at the Sendai plant on Kyushu island in Japan's south-west will soon receive final approval for a restart. Why Sendai is to lead the way isn't totally clear, but the support



of the prefectural governor may be one reason.

The Sendai plant faces some specific risks. The site is about 50 kilometres from a large active volcano, Sakurajima, and there are several other active volcanoes on Kyushu. A large eruption would pose obvious safety issues for the plant, but its operator has said that advance warnings of an impending eruption would allow them to take appropriate measures. Doubts about this sanguine view were reinforced by the eruption of Mount Ontake on Honshu, without warning, in September. It killed more than 50 climbers

out for a weekend stroll.

A variety of natural hazards, including earthquakes and subsequent tsunamis, pose risks to reactors throughout Japan. I have written extensively about the lack of success of both short and long-term earthquake prediction (*Nature*, vol 472, p 407). It is well known that accurate predictions of fracture and failure phenomena such as earthquakes are, in general, impossible. Intellectually honest discussions

"The bottom line won't change. There is no way to ensure absolute safety of nuclear power plants"

of nuclear safety with regard to earthquakes must start by acknowledging this.

Before Tohoku, the Japanese government's seismic hazard map assumed that earthquakes off that coast would not exceed magnitude 7.5 to 8.0. The most authoritative estimate for the size of the Tohoku quake is magnitude 9.1. Given that the energy released by an earthquake increases 30-fold for every 1.0 increase in magnitude, this is a huge discrepancy.

Despite the semi-random nature of these hazard forecasts, the fact that they were promulgated by government scientists has provided an alibi of sorts. No one has been held individually accountable for the nuclear disaster that unfolded at Fukushima Daiichi.

There was some positive news amid the disaster. The Onagawa plant, about 100 kilometres north of Fukushima Daiichi on Honshu's Pacific coast, was hit by a roughly comparable tsunami, but a combination of a more stringent tsunami design standard, good engineering practice and a bit of good luck meant that there was no significant damage.

Both pro- and anti-nuclear advocates have argued that nuclear plants should be restarted if and only if they can withstand a "worst-case" scenario – albeit with each side trying to game the definition of the worst case. This may sound sensible, but it is logically flawed. When it comes to natural hazards there is no "worst case". If we ratchet up the definition of worst case to

magnitude 9.1, and ensure plants exceed the standards of Onagawa, will earthquake and tsunami safety be assured?

Absolutely not. Geophysicists David Jackson and Yan Kagan of the University of California, Los Angeles, estimate that we can expect one magnitude-10 earthquake in the Tohoku region over the next 10,000 years. And there is a small chance of an even bigger one.

The backdrop to the restart decision is political upheaval, as well as rising carbon emissions and electricity bills amid Japan's increased reliance on imported gas and oil. Prior to the disaster, nuclear supplied about 30 per cent of its electricity.

Before taking power as the major part of a coalition government in 2012, prime minister Shinzo Abe's Liberal Democratic Party pledged to restart nuclear plants if they passed regulatory checks. Now Abe has called a snap election, to be held on 14 December. A change of prime minister or government might well affect the future of nuclear energy in Japan.

But regardless of who is in power, the bottom line won't change. There is no way to ensure absolute safety of nuclear power plants (or for that matter, anything else). The possibility of earthquakes and other natural hazards in excess of the design specifications has to be accepted from the outset. Plants must be designed to be "fail-soft", so that earthquake damage is minimised and there is no massive release of radioactive material into the environment.

And although advice from specialists is necessary, it is Japan's political leaders, as well as the voters who elect them, who must take ultimate responsibility for the decision to restart its nuclear plants. ■

Robert J. Geller is professor of geophysics at the University of Tokyo

ONE MINUTE INTERVIEW

Back to making people fly

In designing its first crewed spacecraft in decades, NASA called on **Owen Morris**, a veteran of the Apollo and space shuttle eras



PROFILE

Owen Morris was a manager in both the Apollo and space shuttle programmes. He consulted for NASA on the development of its Orion crew capsule (pictured). On 4 December, an uncrewed Orion will blast off, orbit the Earth twice and splash down

What inspired you to get into space travel?

I've been interested in things that fly since I was a kid. I got degrees in aerospace engineering, applied to NASA and stayed there for my entire career.

What did you work on at NASA?

During Apollo, when we started the lunar module project, I was the chief engineer. Later, I managed the entire Apollo spacecraft programme. In the shuttle programme, I was manager of systems integration and systems engineering.

NASA summoned you back as a consultant on their next spacecraft, Orion. Why did they call on you?

NASA has not developed a big new vehicle since the shuttle. Most of the people that worked on the shuttle are now retired, so those starting the Orion programme didn't have the shuttle people to advise them. That's what I've been trying to help a bit on.

Does it matter that NASA lacks recent experience in designing a spaceship?

With the tools they have now, the people conducting the Orion programme are much more technically capable than we were back in the Apollo and shuttle days. For example, we knew what the aerodynamics equations for Apollo were, but we could not solve them in any detail with the computers we had at the time. Now they can.

No human has left low Earth orbit for more than 40 years. Where can Orion take us?

The big capability of Orion and its rocket, the Space Launch System, will be to let us do things in deeper space again. It's good for trips that would last three weeks or so, depending on the size of the crew or the details of the mission. You can go to a captured asteroid. To get to Mars, however, you would need a habitation module in addition to Orion, because of the duration of the trip.

If it were up to you, where would you send future astronaut missions?

It's not in the present space programme, but I would like to establish a space station on the far side of the moon. At that location you're shielded from a lot of radio interference originating on Earth, so it would be good for radio astronomy.

Looking back, what is your most vivid memory of your career at NASA?

The one that always comes to mind is Apollo 13. The service module exploded on the way to the moon, so the lunar module basically had to support the crew all the way to and around the moon. We had to use it to do things it had never done before. I was at NASA for about 85 hours straight. It was a very exciting time.

Would you have gone to space if they had asked you to?

Yes, but I didn't have the chance. For me, though, the fun is in being part of the crew that is designing and developing the vehicles.

Interview by Maggie McKee

Violence for goodness' sake

Most violence doesn't arise from a breakdown of morality – quite the opposite, say **Alan Page Fiske** and **Tage Shakti Rai**

WHY would anyone hurt you? Why would you hurt or kill someone else? Contrary to popular perception, people are rarely violent simply because they lose control and fail to think about right and wrong. They rarely commit violence because they lack empathy and fail to see their victims as fully human. And almost no one is violent because they draw sadistic pleasure from the suffering of others.

Across cultures and history, there is generally one motive for hurting or killing: people are violent because it feels like the right thing to do. They feel morally obliged to do it.

Loss of control, lack of empathy, dehumanisation, self-interest: these are factors that help facilitate violence, but none of them account for the motives underlying most acts of violence. When people impulsively lash out, on the whole they don't simply lash out randomly. The truth is that people engage in violence when they feel it is the morally right thing to do. Violence is not a breakdown of morality – it is motivated by moral emotions and judgements.

To claim that people are morally motivated to hurt and kill others might sound like a contradiction in terms. This is because many people in the West have been taught to equate morality with the avoidance of pain and suffering. But as laudable as this stance may be, we cannot allow it to cloud our scientific description of the moral psychology that guides human actions.

So here, when we use the term “moral”, we mean “moral from the perpetrator's point of view”. When we say that violence is morally motivated, we are not justifying violence; we are simply describing the motives, emotions and judgements of the person committing the violence. We ourselves judge violence to be repugnant, but it is crucial to acknowledge the empirical fact that morality – the sense of

“ought”, “should”, or “must” – varies between cultures and changes across time. However, violence always functions to create, sustain and otherwise regulate our social relationships. A person's moral psychology is not fundamentally or intrinsically oriented toward harm-avoidance, peacefulness or altruism. Ultimately, morality is about regulating relationships, and violence is a powerful means to do so.

Driven by love

If your parents spanked you when you were a child, it was probably because they thought it was good for you. They may have hated to do it, but they did it because they felt they had to, to bring you up correctly. Their parents may have spanked or whipped them in order to raise them as God-fearing, virtuous adults.

Looking more broadly, violence – the deliberate infliction of pain, suffering, fear, injury or death – has long been an integral part of many people's lives around the world. Violent initiations, for instance, create strong communal ties that bind participants to sacrifice their lives for each other. Likewise, the brutal self-inflicted harm formerly committed by Native Americans on their spirit-quests creates an irrevocable relationship with a spirit guardian who would empower and protect them in battle. In many cultures, some form of surgical modification of the genitals of men or women is felt to be essential to the creation of a virtuous adult, even – and sometimes especially – if it is frightening and painful.

When a woman shoots an intruder to protect her children, it is love for her children that motivates her. Likewise, soldiers often kill to protect their buddies. Some violent acts are punitive – the execution of a



PROFILE

Alan Page Fiske is an anthropologist at the University of California, Los Angeles. **Tage Shakti Rai** is a psychologist at the Ford Center for Global Citizenship at Northwestern University in Evanston, Illinois. They are authors of *Virtuous Violence: Hurting and killing to create, sustain, end, and honor social relationships*

murderer for example, or the bombing of those who bomb us. That's justice as the perpetrator perceives it – an eye for an eye, a tooth for a tooth.

In some cultures, when someone dies, the principal mourners cut or burn themselves or amputate a finger joint. In some old civilisations, wives and retainers were killed to accompany the spirit of a dead king, or captives were sacrificed in his honour. Thus they honoured the dead, showing their love and commitment.

A person may also harm someone to morally regulate a relationship with someone else. For instance, a youth who wants to join



Sometimes a moral code dictates that people have to sort out a situation themselves

deserve violence, and may even relish the pain the victim experiences.

Instead, we must reorient potential perpetrators to find non-violent ways to regulate their relationships. Moreover, we must make perpetrators know that their violent actions will violate their relationships with people they care about. Family, friends and leaders must show potential perpetrators that they won't put up with violence. They must make it clear that if the perpetrator injures or kills anyone, they won't just hurt the victim, they will damage their relationships with family, friends and community leaders.

When, for instance, non-violent African American protesters were hosed and beaten during the civil rights movement, it did not evoke guilt in the majority of white American southerners, but it did elicit the sympathy of the northern states and the international community, and as a result the American South was shamed and pressured into tolerating integration.

Likewise in US cities plagued by gang violence and homicide, the most successful violence-reduction programmes rely on communicating to gang members that their violence is not praiseworthy and that it is hurting the people they care most about. For example, in the Cure Violence programme – previously known as CeaseFire – in Baltimore, Maryland, influential local leaders, speaking for the community, publicly tell the principal perpetrators that killing is intolerable, and victims and bereaved families confront the killers with the social consequences of killing. Swift and certain legal sanctions are used alongside these meetings, but are insufficient by themselves: family members and respected community leaders must clearly and forcefully state that violence is wrong.

Changing people's motives and beliefs about violence is difficult and takes time, but that is true of many cultural changes in values and practices. Extreme corporal punishment of youngsters used to be ubiquitous, but is now in steep decline and widely judged to be child abuse. Domestic violence used to be commonplace and explicitly condoned; now, an incident of family violence can dominate a news cycle and be widely condemned.

Violence is already less condoned and practised than it used to be. We have a long way to go, but we have the power to stop violence by making it immoral. ■

the Bloods gang may have to kill a member of the Crips gang first. In a culture of honour, a man is morally obliged to attack someone who insults his wife or mother.

In short, most violence is morally motivated to create, conduct, protect, redress, terminate or mourn crucial relationships, according to the cultural norms of the group that people belong to.

None of this negates the fact that people also have strong motives of care and compassion towards those they have communal or pastoral responsibility for. And none of this negates the fact that most of us find committing acts of violence repugnant and traumatic. But moral motives to do harm may grow strong enough to compel a person to be violent. This may happen in an instant, so they do not have time to reflect on the wider moral implications of their violence. Or a person may carefully ruminate about the morality of violence for years while awaiting the right opportunity to violently regulate a

relationship. But the motives are equally “moral” in either case.

The foundation of Western legal systems is that people are found guilty and punished for intentionally doing what they know to be wrong. But what happens when people know that what they did was right, according to their internal moral compass? If we wish

“People rarely commit violence because they are sadistic or lack empathy”

to reduce violence, simply increasing the penalties will not work, because people will do what is morally required if they feel their cause is righteous – whatever the consequences. It will not reduce violence to simply teach people to step back and consider the victim's feelings and whether the victim deserves harm, because often the perpetrator may decide the victim does

STANISLAS GUIGUIGNE VU/CAMERA PRESS

Tin soldiers

From Tim Stevenson

The complex issues of robot war that Chris Baraniuk discusses (15 November, p 38) can be boiled down to three questions.

First, do we accept the utilitarian principle that we should choose the option that maximises good and minimises harm, rather than being driven by absolute principles?

Second, do we agree that violence is the optimal way to achieve this objective? And third, is our technology sufficiently advanced that machines can do this better than fallible but still far more complex humans?

Great Missenden,
Buckinghamshire, UK



From Ted Lovesey

Chris Baraniuk discusses whether robot weapons should be banned. There is a long history of bans on new weapons technology, but most have met with little success.

As early as 1139, Pope Innocent II, agreed to ban the use of the crossbow against Christians.

Richard I failed to differentiate between Christians in France and Muslims in the Holy Lands when deploying his crossbowmen. This resulted in the ban disappearing quickly without trace.

Stoke Gabriel, Devon, UK

From Bryn Glover

The implicit assumption in your article is that robotic weapons would be deployed against human combatants. This ignores

the facts about arms acquisition in the modern world.

In many conflicts, the same manufacturer may ultimately have provided the weapons used by both sides. This was the case in the 1980 war between Iran and Iraq, where British weapons were procured by both nations.

What happens when both sides send in the same robots? Do we apply the principle of warfare expressed by first world war general Douglas Haig that both sides keep shooting until one combatant is left? Do we revert to human versus human trench warfare? Or do we all realise the stupid futility of it all, have a good laugh at ourselves and settle down to peaceful coexistence?

Glasshouses, Harrogate, UK

Picture this

From Pamela Protheroe

Tiffany O'Callaghan explores fears that reading on screens will have detrimental effects on the development of literacy skills (1 November, p 40).

It's unfortunate how many people hold strong positions on this, given that we have "such a shallow knowledge base", as researcher Anne Mangan notes.

This is opposite to my own concerns, about the effect picture books have on the development of reading skills. In this case, the knowledge base is vast but almost nobody takes a strong position on the issue.

Dozens of researchers from the 1960s to the present day have produced overwhelming evidence that picture books are harmful to the development of reading – and they have been ignored.

Even the best young readers read more slowly and make more mistakes when pictures are present. I wrote about it for your magazine (19 June 1993, p 44), and have since completed a doctoral thesis on the subject.

As literacy levels continue to plummet, more use is made of the very teaching material that has been proven to be a major contributor to this situation.

I wish current researchers success in getting educationalists to heed their results about reading in the age of digitisation.
Upper Hutt, New Zealand

Without a trace

From Jonathan Oates

As a recent biographer of John George Haigh, the "acid bath murderer", I was interested to read Erwin Vermeij's article on the science of dissolving bodies (8 November, p 44).

I would take issue with two points, however. First, Haigh was only convicted of killing one person, Henrietta Helen Olivia Roberts Durand-Deacon, although he undoubtedly killed six people.

Second, acid will eventually destroy all organic remains, and if there's no investigation, the killer is safe. Nothing was ever found of Haigh's first five victims.

The remains of three were flushed down the drain of a basement flat on Gloucester Road, London. A year later when Durand-Deacon's remains



were found in the rubbish near Haigh's shed in Crawley, there was no evidence left of the two victims also dumped nearby.
Iver, Buckinghamshire, UK

Fuelling change

From Nigel Williams

Why does anyone suggest, as Paul Younger does, that divesting from the fossil fuel industry would cause more fuel poverty (15 November, p 26)?

Fossil fuel exploration subsidies in the UK total £750 million a year on average, largely as a result of tax exemptions for oil and gas activities in certain types of fields. These activities would not happen unless supported by taxpayers, and this money could instead be used to relieve poverty.

Worldwide, the fossil fuel industry receives more support from governments than renewables. If this was withdrawn then renewables and energy storage could compete successfully with fossil fuels.
Leek, Staffordshire, UK

From Perry Bebbington

In justifying his stance against divestment, Paul Younger mentions that our plastics rely on fossil fuels.

Surely when oil is made into plastic, the oil should not be referred to as a fuel – fossil or otherwise. It is more akin to "plastic ore" in the same way that iron ore is used for making iron. Carbon locked into plastics does not contribute to global warming.
Kimberley, Nottinghamshire, UK

Trading places

From Chris London

I was very pleased to read your articles exploring the Transatlantic Trade and Investment Partnership (TTIP) (1 November, p 32).

I live in New Zealand, where a similar trade deal, the Trans-Pacific Partnership (TPP) agreement, is being negotiated for the region, likewise undertaken in near-total secrecy.

No useful information is coming from the mainstream

print or broadcast media in this part of the world.

From what I have been able to glean, it appears that the TPP would effectively mean that laws and regulations would have to be made for the benefit of US corporations, even to the detriment of the other parties to the deal. I suspect that the end result would be very similar to that expected of TTIP.

Milton, New Zealand

The birdie song

From Guy Cox

Whatever one may think of the hermit thrush, nobody who has listened to Australian butcherbirds can doubt that birds make music (8 November, p 12).

Their varied songs can all be transcribed – both pitch and rhythm – into Western notation. Many Australian composers have used their songs, and Brett Dean even incorporated an actual recording in his *Pastoral Symphony*.

Furthermore, butcherbirds use other “human” musical tricks such as adding ornamentation, or singing a melody followed by its inversion. They duet with others, and even with different species such as the Australian magpie.

I once got a butcherbird to duet with me by whistling its song back to it. The bird replied, slightly changing the melody. This delightful musical conversation carried on for a minute or two before it flew away.

Sydney, New South Wales, Australia

Age of polyethylene

From Rob Ellis

Jan Zalasiewicz ponders whether human action has pushed Earth into a new geological age (8 November, p 26).

Discussing anthropogenic changes like new minerals (concrete being an example),

one other unique long-lasting material was omitted – plastic. This material is possibly more widespread than any. With that in mind, we could call the new age the Plasticene.

Sutton Coldfield, UK

Climate control

From Liam O’Keeffe

I was deeply shocked to read that the Intergovernmental Panel on Climate Change (IPCC) calculated emissions must be “capped at 2.9 trillion tonnes to give a 66 per cent chance of avoiding global warming of more than 2 °C”, widely held to be the threshold for dangerous climate change (8 November, p 8).

By implication, there is a 33 per cent chance that warming will be more than 2 °C, even if emissions are capped successfully.

Those don’t sound like good odds to me. If I was in charge of the IPCC, I would therefore be encouraging investment into geoengineering.

This may not be the best solution, nor the least controversial, but it may buy us time if the odds go against us or, at the very least, allow us to mitigate some of the worst effects of dangerous climate change.

Abinger Hammer, Surrey, UK

Air power

From Andrew Giegel

Steve Orchard illustrates the inefficiencies of storing excess wind power as compressed air (15 November, p 31).

Compressed air isn’t the best option for storing energy unless one has a proper use for the huge quantities of very cold air that will be available when the bottled air is released.

Combining wind-powered air compression with a gas-fired power turbine is a much better bet, thermodynamically. Gas turbines require air to be heavily

compressed before it is mixed with fuel and burned, a process that requires a lot of energy.

Having “pre-compressed” air on tap makes it possible to operate a gas turbine generator set at remarkably high efficiency.

These compressorless gas turbines needn’t consume fossil fuel. They could burn biogas, or liquid biofuels.

Admittedly, compressing air does produce a significant amount of heat, as Orchard says. However, that heat needn’t go to waste either: manufacturing plants or district heating systems could certainly exploit it.

Moorlynch, Somerset, UK

Sleep furiously

From William Bains

Looking at the difference between skinny and larger people, Linda Geddes comments that inactive skinny people move about more during the day, but may also burn more calories at night (15 November, p 32).

Perhaps this is also due to moving about more? Individuals’



movement during sleep varies enormously.

In our house, the skinnier person is notorious for dragging the covers into an untidy heap, while the one who is larger leaves the bed looking as though it has hardly been slept in.

Perhaps a hidden cause of the obesity epidemic is that modern beds are just too comfortable.

Melbourne, Australia

Reef relief

From Martin Savage

Michael Slezak refers to the widespread coral bleaching seen during the last spike in ocean temperatures as evidence of the harm these changes have caused (15 November, p 8).

However, coral bleaching – the expulsion of symbiotic algae by the coral – is an adaptive response, akin to sweating in humans. In most cases, the organism will return to normal as soon as the temperature falls to a more agreeable level.

Only if the raised temperature is sustained for a long time will the coral die. It should also be noted that corals are not as delicate as some people believe, otherwise they wouldn’t be able to ride out the coming and going of ice ages.

Jomtien, Thailand

Quantum countdown

From Brian Smith

The illustration accompanying your piece on the first run of historic quantum software (1 November, p 10) was captioned with the phrase “Testing, 1, 2, 3”. But surely it should have been “0, 1, both”?

Berlin, Germany

For the record

■ **Flight of fancy:** we referred to Lynn Rothschild as creator of a biodegradable drone; in fact she led the team that created it (15 November, p 21).

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TOXIC SHOCKERS

Our food, furniture and frankly everything else is contaminated with industrial compounds – but how harmful are they? *New Scientist* investigates

TAKE a bite out of a fresh apple: there's nothing as healthy or natural. The problem is that science tells us otherwise: sensitive tests reveal that pretty much everything in the modern world – fresh fruit included – comes with a cocktail of chemical extras.

Some of these extras are welcome, but others are not. Consider that apple. In a study by the US Department of Agriculture, almost every apple tested contained residues of insecticides, fungicides and herbicides. Look hard enough and it is much the same story whichever food you examine.

Nor is it just our eating habits that expose us to these pollutants – we pick up tiny doses from cosmetics and paper, from the cushions and fabrics we sit on, the water we drink and the air we breathe.

Before you choke on your snack, bear in mind that most of these doses fall well below the levels considered harmful by regulators, while others don't have any discernible effect on the human body. But there are a few whose safety is disputed both by experts and in the popular press.

Over the next five pages, we explain what we know about nine of the most frequently suspected substances.



ANTIMICROBIALS

Want to keep your mouth fresh, armpits smelling sweet and feet fungus-free? Triclosan's antimicrobial clout has a wide reach: it is added to many products including soap, toothpaste and cosmetics. But in 1998, a report suggested that triclosan might be contributing to antibiotic resistance. Then in 2007, concerns emerged that the antimicrobial might alter hormone regulation in rats. Triclosan has since been scrutinised closely by regulatory bodies and scientists globally.

The concern in the rat studies was that triclosan disrupted the endocrine system – in particular thyroid function – when the rats were fed high doses of the stuff. Animal models don't necessarily translate to humans. However, the US Environmental Protection Agency (EPA) is keeping a close eye on triclosan's potential health effects: it has brought forward its scheduled review by 10 years. The EPA reports that there is a low-level risk to some aquatic life, particularly algae, from water that has triclosan in it. There are even indications that triclosan may not make hand-washing more effective – a number of manufacturers, among them Johnson & Johnson and Procter & Gamble, have decided to eliminate the ingredient from their products. This year, Minnesota became the first US state to legally restrict its use.

In Europe, the question of antibiotic resistance is still being investigated. The European Commission's Scientific Committee on Consumer Safety says that triclosan is still safe to use, but admits there are gaps in knowledge.

VERDICT

There's no direct evidence that triclosan damages human health, but it's under close scrutiny.

Katharine Sanderson

STAIN RESISTERS

We owe the delights of nonstick cookware, waterproof clothing, stain-proof carpets and even dental floss to perfluorinated chemicals (PFCs), first produced industrially in the 1940s. These substances are marvellous at repelling grease and water, but a number of studies show that we all carry traces of them in our blood.

Two of the most common PFCs found in humans and the environment are perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). Thanks to their long molecular backbones and super-strong carbon-fluorine bonds, these chemicals are remarkably difficult to break down and so they persist in the environment for years. Animal studies suggest that long-chain PFCs may alter hormone levels and cause cancer. Human studies suggest that these chemicals may lead to thyroid disease and raised cholesterol levels among other things.

In 2009, PFOS was added to the list of chemicals banned under an international environmental treaty called the Stockholm Convention on Persistent Organic Pollutants. Eight major manufacturers have signed up to a US Environmental Protection Agency programme to eliminate the use of PFOA by 2015.

Manufacturers have also switched to shorter-chain PFCs, which should degrade more easily. Yet these chemicals are also a cause for concern.

Take perfluorobutane sulfonate (PFBS). This is broken down in our bodies in days, so experts had not expected it to accumulate inside us. Yet a 2012 Swedish study found that the concentration of PFBS is increasing dramatically in our blood, doubling every six years – although concentrations remain relatively low.

There are other mysteries to solve. While the levels of PFOS and PFOA in blood are falling, PFOA concentrations have not declined as much as predicted. Scott Mabury at the University of Toronto in Canada suggests that might be because other fluorinated chemicals are converted to PFOA in our bodies. Chemicals called polyfluoroalkyl phosphate esters, widely used in greaseproof food wrappers, could be one source, he says. These chemicals have been detected in human blood, and animal studies suggest they can transfer from packaging into food.

Worse, Mabury says that tests on blood reveal a number of organofluorine compounds of which almost half cannot be identified. "This suggests there are new chemicals on the market that we have not measured yet."

VERDICT

A widespread, persistent family of chemicals with evidence of impact on human health. **Emma Davies**



OF 5.7 MILLION TONNES OF POLLUTANTS RELEASED IN NORTH AMERICA:

- 1.8 MILLION TONNES CONSIDERED PERSISTENT, BIOACCUMULATIVE OR TOXIC
- 970,000 TONNES KNOWN OR SUSPECTED CARCINOGENS
- 857,000 TONNES CONSIDERED REPRODUCTIVE OR DEVELOPMENTAL TOXICANTS

(UNITED NATIONS ENVIRONMENT PROGRAMME)

COSMETICS

In 2004, journalists and consumers got in a spin over chemical preservatives called parabens, when a study suggested that parabens were present in 20 breast cancer tissue samples, and linked the disease to cosmetics such as deodorants (*Journal of Applied Toxicology*, vol 24, p 5).

This sparked a long-running debate about the safety of parabens. But evidence that links them to breast cancer has been elusive, and regulatory bodies, including the US Food and Drug Administration and the European Union's Scientific Committee on Consumer Safety maintain that, although parabens are thought to disrupt the endocrine system, the low doses in cosmetics are safe. What's more, most underarm deodorants don't contain parabens.

In 2012, another study into a possible link between parabens and breast cancer from the same researchers prompted UK charity Breakthrough Breast Cancer to speak out. "This research has serious flaws and provides no proof to suggest that women should be concerned about parabens."

Alan Boobis, director of the Public Health England Toxicology Unit at Imperial

College London, agrees: "Parabens really aren't very harmful," he says. Animals exposed to "really quite high" levels experience no adverse effects, he says. "That is a consistent finding."

Despite a lack of pressure from regulatory bodies, cosmetics companies have started to remove parabens and other chemicals from their products. "It's because of public pressure," says Boobis.

VERDICT

There's no convincing evidence that parabens in cosmetics damage human health. KS

PLASTICS

Phthalates are often added to plastics to increase their flexibility, but also turn up in a huge variety of other places, from pill coatings to printing inks. As a result, low levels of this group of chemicals are found in almost all of the people tested by the US Centers for Disease Control and Prevention.

Bad news? They have been identified as possible disrupters of the human endocrine system, but their health effects at low concentrations are unclear. Exposure at high levels is linked to lower sperm count and anatomical deformities in newborns, although this link has also been seen in groups exposed to regular levels of phthalates. "Our knowledge of phthalates largely comes from animal studies," says Laura Vandenberg at the University of Massachusetts, Amherst.

VERDICT

Phthalates' effects on human health are unclear. They are so widespread that they are difficult to avoid.

FIRE FIGHTERS

Making furniture and fabrics resistant to fire seems like a no-brainer. Yet many flame-retardant chemicals pose a serious risk to health.

One group – the polybrominated diphenyl ethers (PBDEs) – comes in hundreds of forms, from penta- to decabrominated diphenyl ethers. Until recently, these substances were used in a vast array of products, from electronics to bedding. Many have now been banned or withdrawn in the EU and the US over concerns about reduced fertility and impaired development in children.

However, concentrations of PBDEs in people in North America have doubled every five years since the 1970s, and relatively high levels are found in house dust.

How the chemicals escape from furniture "is still a big unknown", says Heather Stapleton, an expert on flame retardants at Duke University in Durham, North Carolina. They may get into air pockets in cushions, she says, and enter the air when someone sits down. Foam can also rub off to form dust, she adds.

Linda Birnbaum, director of the US National Institute of Environmental Health Sciences in North Carolina, is particularly worried by another chemical called tetrabromobisphenol A (TBBPA), which has largely "fallen under the radar" despite being used in phenomenal quantities worldwide.

Research from the US National Toxicology Program showed that TBBPA causes cancer in rodents. There is also evidence that the chemical is an endocrine disruptor, affecting both thyroid hormones and oestrogen signalling, says Birnbaum. She has found that TBBPA can inhibit an enzyme that metabolises oestrogen, leading to elevated levels of the hormone in the body.

TBBPA is often used as a substitute for the banned deca-BDE, primarily in electronics, but too little is known about the new chemicals replacing banned retardants, says Birnbaum. "For some of the chemicals, what little information we have is very concerning," she says.

Take chlorinated tris (TDCPP), which was banned from use in children's pyjamas in the 1970s after it was found to cause cancer in animals. This chemical is still used in furniture, often as a replacement for penta-BDE.

VERDICT

Harmful retardants remain widespread. New ones may need more testing. ED





METALS

There might be no lead in vehicle fumes nowadays, but it is still getting into our bodies. "Lead is re-emerging as a problem," says Alan Boobis, director of the Public Health England Toxicology Unit at Imperial College London.

Lead exposure has dropped dramatically since the 1970s, especially in the EU after it was banned in petrol and regulated in pipes and paints. But all the lead that has been released over the years has made it into the soil, and so we end up eating it in our food. The main culprits are cereals, with vegetables and tap water also contributing. Avoiding lead is virtually impossible.

In 2010 the European Food

Safety Authority (EFSA) reduced its recommended threshold for lead in the body, and concluded that a measure that used to be called a provisional tolerable weekly intake was no longer appropriate. "There is no safe blood lead level," says Boobis. "Even at low levels, lead seems to be associated with lower IQ," he says. Babies and children are most at risk.

Mercury too, remains a concern. Unlike lead, mercury accumulates in the food chain and top-predator fish are our main dietary source. Too much mercury can result in developmental damage in babies and small children. A new study shows that mercury levels have



**TESTS SHOWED
12,000 OUT OF
77,000 SAMPLES
FROM 500 DIFFERENT
FOODS CONTAINED
PESTICIDE LEVELS
EXCEEDING
EUROPEAN LEGAL
LIMITS**
(EUROPEAN FOOD
SAFETY AUTHORITY)

tripled in surface waters, especially around Iceland and Antarctica, yet this represents just a quarter of the total amount released by industry. The rest, researchers suggest, is probably in ocean sediments.

The one place where mercury is closest to us is possibly the place where we should fear it least: mercury amalgam tooth fillings. "The amount of mercury that comes out is so low it has little effect," says Boobis.

VERDICT

Guilty as charged. Mercury intake can be reduced by avoiding predatory fish. KS

PESTICIDES

Many pesticides are designed to poison nervous systems, but toxicologist Rudy Richardson at the University of Michigan School of Public Health in Ann Arbor says we shouldn't worry too much: these neurotoxins are not wantonly sprayed on our food. "These compounds are probably the most strictly regulated of all types of chemical substances." Yet even regulators don't always agree on risks - the herbicide atrazine, for example, is banned in the EU but widely used in the US.

Traces of pesticides are now widespread in the environment. The US Centers for Disease Control and Prevention has shown that most Americans have very low concentrations of organophosphate pesticides in their urine, and surveys by the US Department of Agriculture have found that many kinds of fruit and vegetables contain tiny amounts of pesticide residues. Although these are below levels deemed dangerous by regulators, pesticide use is on the up. This worries environmental scientist Laura Vandenberg at the University of Massachusetts, Amherst. "Pesticides are designed to be biologically active," she notes.

Studies link exposure to organophosphate pesticides in pregnancy to delays in childhood development and autism, and suggest they may also play a role in cardiovascular disease. A review of epidemiological studies published in *The Lancet Neurology* suggests that a common organophosphate pesticide, chlorpyrifos, can damage human brain development (vol 13, p 330). And according to Linda Birnbaum, director of the US National Institute of Environmental Health Sciences in North Carolina, there is evidence that pesticide exposure may increase the risk of developing diabetes and obesity.

In 2012, the EU completed a review of 1000 pesticides that led to the withdrawal of about 700 older chemicals from the market. The US Environmental Protection Agency has a programme to speed up the registration of new, safer alternatives to older pesticides.

VERDICT

Pesticides can be harmful. Despite tight controls, they do get into food. KS

BURNT FOOD

Your morning coffee and toast, it seems, could be hurting you. In 2002, Swedish researchers reported that acrylamide, a chemical linked to cancer in rodents, is present in some cooked foods at surprisingly high levels.

Acrylamide forms when plant-based foods rich in carbohydrates are baked, fried or roasted at high temperatures. The chemical is created as part of a browning reaction involving sugars and an amino acid called asparagine, and adds to a food's appeal by creating flavour and colour. Since acrylamide is highly water-soluble, it is absorbed from the gut and then distributed to tissues. Animal studies suggest that acrylamide has the potential to cause cancer, possibly by forming a substance called glycidamide in the body, which is widely distributed into tissues.

According to the European Food Safety Authority (EFSA) Panel on Contaminants in the Food Chain – which has pored over vast numbers of studies – foods such as chips, breakfast cereals, biscuits and breads all contain acrylamide. Its draft report, released for consultation in July 2014, states that eating acrylamide “potentially increases the risk of developing cancer” and reveals that coffee and fried or roast potatoes are the worst offenders.

Some research also links the chemical to effects on the nervous and

reproductive system in rodents. A recent study by a collaboration between the Norwegian Institute of Public Health and Stockholm University suggests that pregnant women exposed to higher levels of acrylamide had smaller babies. Yet the EFSA makes it clear that studies have “not demonstrated acrylamide to be a human carcinogen”.

That hasn't prevented a lawsuit in the US claiming that food manufacturers had failed to warn consumers about the dangers of acrylamide. As a result, acrylamide must be labelled in consumer products in California and some manufacturers have agreed to reduce levels of the chemical in their foods.

Unfortunately, acrylamide is nigh on impossible to avoid if you enjoy tasty, starch-rich foods. But there are ways to limit consumption. Toast can be eaten golden rather than darker brown, and research has shown that a short espresso has less acrylamide than a lungo, which takes twice as long to prepare.

For now, the EFSA recommends avoiding overcooking and excessive crisping. “Don't burn it, lightly brown it,” goes the advice.

VERDICT

Despite lingering concerns, acrylamide in food is not a confirmed carcinogen in humans. **ED**



20 KILOGRAMS OF PHARMACEUTICALS FLOW DOWN ITALY'S PO RIVER DAILY.

(MARIO NEGRI INSTITUTE FOR PHARMACOLOGICAL RESEARCH)

PACKAGING

The coating of till receipts, food-tin linings and polycarbonate plastics all contain a synthetic oestrogen that has been mired in controversy for more than a decade. That's because the compound, the plasticiser bisphenol A (BPA), has the potential to influence hormonal systems in mammals.

After tests by the US Centers for Disease Control and Prevention found BPA in

more than 90 per cent of Americans, and the US National Toxicology Program expressed concern over its effects on the brains and behaviour of young children, the Food and Drug Administration banned the chemical from babies' bottles in 2012.

In Europe, a similar ban came into force in 2011, and the committee for risk assessment at the European Chemicals Agency, which

advises EU regulators, announced that BPA is a “presumed human reproductive toxicant”. Yet while BPA's impact has been confirmed in animals, its action is hard to prove in humans, in part because our bodies rapidly convert it to a form that exhibits no oestrogen-like activity.

While some researchers and campaigners argue that current safety levels are

not stringent enough, attention is turning to BPA's replacement, bisphenol S. This has a similar structure and one study says it may also act like oestrogen.

BPA is just one of many potential “endocrine-disrupting” chemicals we are exposed to. In 2013, 85 scientists signed a document demanding tougher regulation in Europe. The Berlaymont Declaration on Endocrine

Disrupters pointed to rising levels of cancer, plus brain, thyroid and reproductive problems, and suggested that the rate of increase in endocrine-related diseases cannot be explained by genetics or lifestyle alone.

VERDICT

BPA may be just one of many endocrine disrupters damaging human health. **ED**





UP TO OUR NECKS IN CHEMICALS

Understanding the risks posed by additives and contaminants seems like a mission impossible. For a start, most chemicals are only tested in animals, and then at high doses, so their impact on humans isn't clear. At the same time, industries make and use synthetic chemicals in so many different forms that without a step change in the way we assess them, there is little chance of quantifying the risks they pose, says Julian Cribb, an Australian journalist and author of *Poisoned Planet*. Even the exact number of chemicals marketed globally is unknown, he says. One guide is the number registered with the EU – which stands at around 144,000. Of these, roughly a third are thought to be harmful, says Cribb, but “the vast majority have not been assessed for human or environmental safety”.

And there are other challenges. The chemicals industry is set to triple in size by 2050, with manufacturing shifting from North America and Europe to nations in Asia and South America.



**IN 2004,
4.9 MILLION DEATHS
WERE ATTRIBUTABLE
TO EXPOSURE TO
SELECTED CHEMICALS**

(WHO)

Many of these places currently lack robust safety regulations.

There have been some successes in the long-term clean-up of our environment. Many countries no longer use asbestos or tetraethyl lead, and the Stockholm Convention lists 25 nasties that are banned or being eliminated from use, including DDT, dioxins and PCBs. Others are under review. Yet this list represents “just a few pixels in a

megapixel image of global toxicity”, Cribb warns. “At the current rate it will take around 50,000 years to assess the remainder.”

Scientists have begun to plot a course of action to tackle this task more swiftly. In the US, for instance, the Toxicology in the 21st Century (Tox21) programme aims to make testing faster and cheaper.

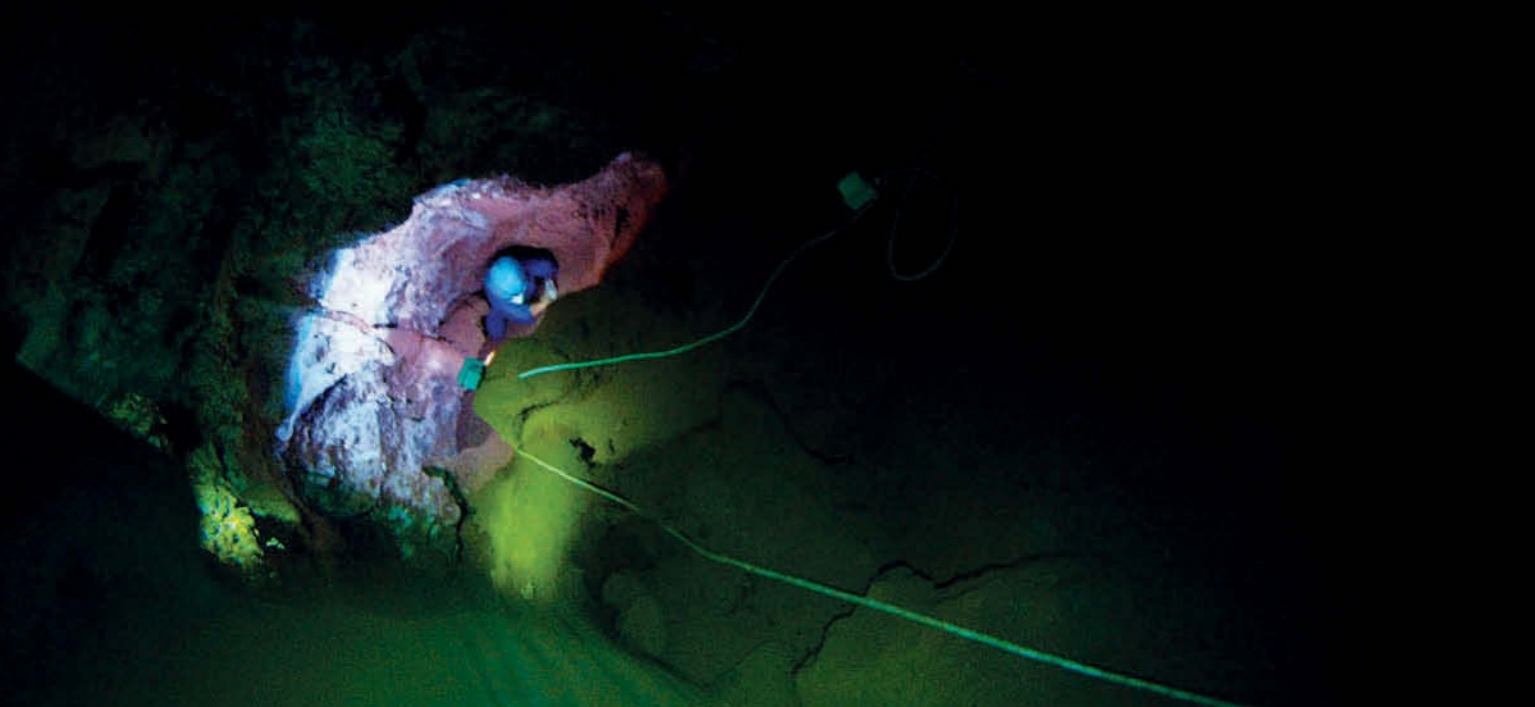
Created by the National Institutes of Health, the Environmental Protection Agency and the Food and Drug Administration, Tox21 aims to examine how 10,000 different chemicals affect human health. To do this, it will use high-throughput screening – made possible by robotics and powerful computers – to run huge numbers of chemical tests. Computers can then seek patterns that reveal how chemicals disrupt pathways in human cells, and gauge their impact on human health. “This will allow us to make decisions without extensive animal testing,” says Linda Birnbaum, director of the National Institute of Environmental Health Sciences in North Carolina.

This strategy offers another benefit. It could reveal if tiny amounts of toxic chemicals interact with each other to make us ill – the so-called “cocktail effect”. This question has troubled experts for many years. Conventional tests examine one chemical at a time, but in the real world we face mixtures of chemicals at doses below those usually thought damaging, such as in vehicle exhausts and cosmetics. Yet there is good evidence for an additive effect in which minute amounts of, say, endocrine disruptors can act together to do harm. The European Commission is in the process of identifying which combinations should be assessed as a priority. Along with high-throughput screening, this may finally offer a way to navigate the complexities of chemical safety. “My hope is that within 10 years we’ll be able to make decisions based on Tox21,” says Birnbaum. ■

Emma Davies and Katharine Sanderson are science journalists based in the UK. Subscribers can find links to the studies in the online version of this article

Chamber of secrets

It could be the greatest ever find of early human remains, and it all began with two inquisitive cavers. Catherine Brahic reports



ALIA GURTOV was still in bed when she saw the job advert in her Facebook feed. “The catch is this,” it read, “the person must be skinny and preferably small. They must not be claustrophobic, they must be fit, they should have some caving experience, climbing experience would be a bonus.” She applied within an hour.

Gurtov wasn’t the only one drawn to the post. Within minutes, it was being liked, re-liked, shared and blogged around the world. Elen Feuerriegel saw it on Tumblr. Marina Elliott received a link by email. “OH. MY. GOD,” wrote one blogger. “LOOK AT WHAT LEE BERGER JUST POSTED TWO MINUTES AGO GUYS.” “What did they fiiiiiiiiind?” wondered a commenter.

At this stage, Berger himself had little idea. The South African fossil hunter famed for his discoveries of early hominids was going on a few photographs. The pictures had been taken a few days earlier by two young cavers, deep inside the Rising Star cave system, 30 kilometres north-west of Johannesburg and 30 metres below ground. The cave is in an area dubbed the Cradle of Humankind because so many hominid fossils have found there. The last big find was made by Berger in 2008: at nearby Malapa, he discovered two partial skeletons of a previously unknown species with a strange mix of apelike and human features – the 2-million-year-old *Australopithecus sediba*.

Now he was on the brink of another major discovery. The photos showed a jaw that

Berger instantly recognised as belonging to some kind of early human – and there were more bones around it. That was enough to make Berger suspect this could be a big find, but what’s been unearthed in this small chamber in the caves has surpassed even his wildest expectations. Back then, though, the immediate question was how on earth to excavate the bones properly in such an inaccessible location.

Set beneath the undulating veld of northern South Africa, the Rising Star cave system has been a playground for cavers for nearly half a century. Thick bush conceals the large opening to the cave. On 13 September last year the two cavers, Steven Tucker and Rick Hunter, made their way down into the maze of dark passages. The pair were hoping to find tunnels that no human had ever set foot in before.

Beneath the Dragon’s Back

Having crept up a narrow ridge known as the Dragon’s Back, with 15-metre drops on either side, Hunter and Tucker arrived in a chamber thought to be a dead end. They had been here before, but on this particular day they found something new. Right at the back of the room, the pair came across a crack in the floor. Peering down, they discovered a narrow chute that appeared to lead into another chamber. “To me that’s really exciting,” says Tucker, “because you have no idea what you’re going to find down there.”

At around 20 centimetres wide, the chute

is so narrow that Tucker had to point his toes just to get in. Undaunted, he began the descent. Falling down *Alice in Wonderland*-style was not likely: Tucker’s body was jammed up against the rock in every direction. Inch by inch he wriggled deeper.

Tucker’s gamble on his small frame and years of experience paid off. Twelve metres down the chute, he emerged through the roof of another chamber and climbed down to the floor. The room was barely 3 metres wide. Flowstones and stalactites dripped from the ceiling and walls, and shimmered in the beam of his head-torch. Looking up, he judged that the ascent would be harder than the descent but – fortunately – not impossible. A narrow passage leading out of the jewelled chamber and on to another was just wide enough to pass through, so he called out for Hunter to join him.

The first thing Tucker remembers seeing when they shuffled through into the next chamber was yet another passageway leading out of it. The bones came second. They were sticking out of the cave floor. “The first thing you think is [the bones] aren’t something small like a bat,” he recalls. “So you wonder, ‘If I struggled that much to get in here, how did these get in?’ That was probably the thing that made us look at them properly.”

Berger had been asking caving clubs to get their members to look out for fossils. So when Tucker and Hunter spotted a jawbone with what looked like human teeth, they snapped a few pictures before moving on. “We had no ➤



A crack just 18 centimetres wide in places is the only way in

ELEN FEUERRIEGEL, RIGHT: MARINA ELLIOTT



ELEN FEUERRIEGEL

The Rising Star cave system was certainly not your average office

idea how important that discovery was,” recalls Tucker. “I’m not sure how many fossils we saw that first time, but when you think of other fossils like Lucy – these didn’t look as impressive.”

Three days later, the pair were in Berger’s office at the University of the Witwatersrand in Johannesburg. When he saw the pictures, his jaw dropped. “I immediately recognised that I was looking at a mandible, and that it was not *Homo sapiens*,” Berger recalls. The jawbone alone would have been thrilling. We know so little about our ancestors that even a single bone can give up a host of secrets.

But it was the fact that there were more bones in the background that made Berger really excited. There might be at least part of a skeleton. “That meant getting those bones out was worth every effort,” he says. “You’ve got to remember that we spend tremendous effort and good old-fashioned money trying to find just bits and pieces of these things. We might spend three months in the field and be very happy if we come back with a single

mandible. That’s how rare these objects are.”

Before the week was out, Berger went to see the cave. He couldn’t fit down the chute, so he sent his teenage son in with Hunter and Tucker. When Matthew saw the bones, his hands began to shake. It was minutes before he could steady them enough to take pictures. “Daddy,” he said after shimmying back up, “it’s beautiful.”

Underground astronauts

Berger’s Facebook appeal for particularly petite potential palaeoanthropologists went online just days later. “Dear Colleagues,” it began, “we need perhaps three or four individuals with excellent excavation skills for a short term project that may kick off as early as November 1st 2013.” It was 6 October.

A year on from Berger’s post, the excitement is still fresh among the six women he recruited – including graduate students Gurtov, of the University of Wisconsin-Madison, and Feuerriegel, of the Australian National University in Canberra. Berger affectionately refers to them as “underground astronauts”. In separate emails and conversations, with moments of intoxicated laughter and genuine passion, they all convey incredulous wonder at what happened in such a short period of time. People were interviewed over Skype, and invited to pack their bags and hop on planes. They flew in from around the world, still mostly clueless about the adventure ahead, thinking simply that it would be fun.

Barely eight weeks after Tucker and Hunter had shimmied down the chute, the expedition was on the ground. They set up camp during the first week of November. In a matter of days, 20 tents went up. Generators powered a collection of computers, lights and cameras, linked to the inner sanctum by a mess of cables. The plan was for the six recruits to retrieve as many bones as they could find, assisted by experienced cavers including Tucker and Hunter. Above ground, a team of somewhat larger senior palaeoanthropologists could watch and supervise everything that



Slimness was an essential requirement for retrieving the bones

was happening beneath their feet, in real time.

Marina Elliott, a PhD student from Simon Fraser University in Burnaby, Canada, was first into the chute. “From the top looking down, the rock looks like a narrow tunnel full of shark’s teeth coming out at odd angles,” she recalls. “Like you’re descending into a jaw. It was kind of terrifying.” At its narrowest, the chute pinches down to 18 centimetres, so narrow that Elliott had to turn her head to the side to get through.

She compares entering the inner chamber to accounts of Howard Carter opening Tutankhamun’s tomb. “Someone behind him said ‘What do you see?’ And Carter whispered, ‘Things, wondrous things’ ... It was breathtaking. Everywhere you turned, your headlamp fell on fossil material... the more you looked the more you found. And it just got crazier from there. Every day was one of those days where you just think, ‘My god, is this real?’”

The six worked in shifts of four or five hours, picking the bones clean with toothpicks before carefully packing them into bubble wrap and Tupperware to begin the long ascent. It quickly became clear that the entire floor of

“It was breathtaking. Everywhere you turned, your headlamp fell on fossil material”



JOHN HAWKS

moved for thousands of years, and that some of the world's biggest experts on prehumans were watching her every move over CCTV.

For Berger, finally seeing the bone for himself was a huge relief. Until that moment, he had not known for sure that the find justified a major expedition involving 60 people from around the world. That day, 10 November, made it all worth it: the jaw was indeed from a hominid.

The next day blew everyone's expectations away. A femur came up, and then another – and they were both right femurs. In the science tent, heads were shaking in disbelief. There was more than one individual down there. “This just doesn't happen,” said Berger. Thousands of hominid fossils have been found but most consist of one or two bones, or the odd tooth. Finding more complete skeletons is extremely rare. Finding several skeletons is rarer still.

And there was more to come. Much more. Before long, the six women were sending a regular stream of Tupperware boxes up to the surface. Hundreds of fossils were carried out of the cave. The senior scientists had expected to have enough time between finds to start analysing the bones, but they could barely log them fast enough.

They ran out of boxes. Someone was sent to buy more. They ran out again. The project bought out the stock of every shop and warehouse that sold Tupperware in the area. The nearby site of Sterkfontein has produced only about 500 hominid fossils after 65 years of excavation. In three weeks, the Rising Star team removed 1200 fossils. Based on the teeth they found, says team member John Hawks of the University of Wisconsin-Madison, there are more than 12 individuals.

It is a mystery how the bones ended up where they did. Tucker, who has explored the

passages beyond the bone chamber, doesn't think there is another way in. He also thinks they have ruled out an accidental fall. Nor is there any sign that the individuals fell victim to predators who carried them in – there are no bite marks, and in any case, how would the predators get in? “I don't think anyone has any real idea of how they got there,” says Tucker.

Bringing up the first piece of skull was one of the more memorable events during those extraordinary days. Wrapped in pink bubble wrap, nestled inside a cereal bowl and packed into Tupperware, it was passed from hand to hand up a human chain. Hunter lodged himself inside the chute and passed it from Elliott below to another caver above. All the way down the Dragon's Back, the team passed the precious parcel in near silence.

“I think for a lot of people, it was very emotional,” says Elliott. “It's extraordinary to think of this animal, that this is an ancestor to all of us.” Whether it is a direct ancestor or more distant branch of the human family remains unclear. Beyond the fact that they are definitely early hominids, the team will not say exactly what they have found ahead of the formal publication of their findings.

Bone bonanza

In the past, hominid fossils have often been hoarded by the researchers who found them. “Ardi”, discovered in Ethiopia in 1994, was only unveiled in 2009, for instance. But we won't have to wait that long this time, as Berger's team is doing things very differently. Around 50 anthropologists were invited to a workshop in South Africa earlier this year. They were given free access to all the fossils – 1500 in total, including 300 unearthed by a second expedition in March – and invited to analyse the heck out of them. Their findings will be announced early next year.

And all the signs point to it being a big announcement. The sheer quantity of fossils is incredible, says team member Steven Churchill of Duke University in Durham, North Carolina. And it's nowhere near over. Not only are there still bones in the original chamber, but in November 2013 Hunter and Tucker found more in a different part of the cave.

“At the end of the day,” says Churchill, “we will know these hominins very well, and we will likely be able to say much about their biology and their place in the human evolutionary story.” ■

the chamber was underlaid with bones, so they padded around barefoot to cause minimal damage. Lifting each fragment was like a delicate game of pick-up-sticks, says Becca Peixotto, a PhD student in anthropology at the American University in Washington DC. “The longer you looked, the more bones you saw. To the point that we'd think we had cleared a whole area, and then we'd sit there for a few minutes and see more fossils.”

She recalls having to lift the first piece of bone out of the ground – it was the jaw spotted by the cavers – aware that it had not been



JOHN HAWKS

CCTV helped the team above ground guide the momentous work under way below

Catherine Brahic is a reporter for *New Scientist*



CLARA MANCINI'S colleagues used to laugh when she talked about her work. Mancini finds ways to improve our experience of interactive technologies. Should there be buttons? How many, how large, what colour? As gadget designers well know, little things can make a big difference.

But Mancini had shifted her focus to a group of users with very different needs. Dogs. "It was very hard at the beginning," says Mancini. "People saw this as something not quite to be taken seriously, as something a little bit funny and cute."

Yet dogs are an integral part of our everyday lives, and that creates a growing need for them to interact with technology. "Dogs are already used in search and rescue, in medicine, as service animals, to help autistic kids and

more," says Alper Bozkurt, an electrical and computer engineer at North Carolina State University in Raleigh who is building a smart harness for dogs. He thinks technology can help rather than hinder. "We'll be able to make them even better at their jobs," he says.

But how do you design tech specifically for an animal? What are their needs? How will they best interact with devices? As research tackles these questions, we are learning how to help them help us better. What's more, insights from working with animals may expand our horizons when it comes to building interfaces for ourselves.

Dogs might chase cars or howl at the TV, but how else do they interact with technology? "I imagined seeing my dog sitting at a keyboard trying to type," says Helen Sharp,

a software engineer at the Open University, UK, where Mancini is also based.

That image may seem bizarre at first, but it's actually not a bad approximation of the challenges many dogs face in performing the tasks we set them. Assistance dogs, for example, are trained to operate light switches or raise the alarm if their diabetic owner collapses. "What changed my mind was hearing about the ways humans ask animals to interact with technology, and then reflecting on how difficult and stressful it must be for them," says Sharp.

We have long been strapping gadgets to animals. Zoologists routinely attach GPS trackers to beasts of the land, air and sea to monitor their movements. The US military has even stuck sensing devices to dolphins and sea lions trained to detect underwater mines.

Crucially, however, none of this technology was designed with the animals' experience in mind. "Users need to be involved in the design process so researchers can know what they really want," says Mancini. That's usually when the jokes begin. "People would say things like, 'How would you get informed consent from a tiger? If it doesn't bite your head off, does that mean it approves?'"

But those turn out to be good questions. How do you design devices for a user that can't tell you what it wants? Mancini's team decided to focus their work on dogs, since they are already thoroughly integrated into our lives. Looking at the animals' anatomy and behaviour is a good starting point.

Lassie gets an upgrade

Gadgets designed especially for animals will enhance their lives as well as ours, says Rachel Nuwer

Nose for precision

When Mancini began trials involving turning on a light, the dogs jumped time and time again for the switch, clumsily pawing at it but often failing to activate it. One expert trainer told her that she could count on dogs not being able to turn on the light even after several attempts. "Service dogs are struggling to do the tasks that are required of them," says Mancini. "For them, operating a tiny, fiddly light switch is very difficult."

Dogs cannot easily distinguish the colour red either, so red alarm buttons and lights don't register. Dogs also categorise objects by size more so than shape, and prefer to use their noses for precision tasks such as hitting a button or turning off a switch.

Taking that into account, the team designed dog-friendly buttons in different sizes and in high-contrast blue and yellow, each activated with the touch of a nose or the slap of a paw. When Mancini presented dogs with them, ➤

they were able to switch on the light at the first try. Such a simple change can make a dog's life a lot easier. "Imagine if you had to use a computer with really teeny-tiny keys and a tiny screen, and that every time you needed to turn on a light you had to jump," she says. "That would stress you very quickly."

In a second project, Mancini and graduate student Charlotte Robinson addressed the lack of any system for medical-assistance dogs to sound the alarm if their diabetic owner should suddenly collapse because their blood sugar has dropped abnormally low. The prototype

"Imagine if you had to jump every time you turned on a light. It would stress you"

alarm is a multicoloured rope that, when pulled with the mouth, sends a message to emergency services.

In July, Mancini and her colleagues exhibited their work at the Royal Society's Summer Science Exhibition in London. A couple of wheelchair-using visitors who brought along their service dogs were delighted when their companions figured out how to work Mancini's interfaces on the spot.

Well-designed devices can help dogs communicate in other ways. Mancini is also working with cancer-detecting dogs, trained to use their sense of smell. Normally, the dogs sit or lie down to indicate the presence of cancer cells in a breath or urine sample, for example, and return to their owners if the sample is negative. However, if dogs are unsure whether what they are sniffing is malignant, they sometimes turn to their owners for help, potentially biasing the evaluation. Like humans, dogs vary in their interpretation of evidence, with some animals more prone to giving false positives than others.

To get around this, Mancini and her colleagues designed a pressure plate that allows dogs to signal their degree of certainty according to how firmly they push on it. The devices are already being used by Medical Detection Dogs, a UK charity that trains dogs to do this work.

Others have gone further, designing what almost amounts to a doggy walkie-talkie. A team at the Georgia Institute of Technology in Atlanta, including Thad Starner, a key developer behind Google's Project Glass, are perfecting an interactive vest for service dogs as part of a project called FIDO – Facilitating Interactions for Dogs with Occupations. The

Designing electronic games for playful young orang-utans could be a way to enrich the lives of those in captivity

POKE TO PLAY

It's not all work and no play in designing interfaces for animals. Hanna Wirman at Hong Kong Polytechnic University has a background in video game design, but ditched human gamers in favour of orang-utans. In Indonesia, many young orang-utans are orphaned when their parents are killed during forest clearance for oil-palm plantations, and may end up living in rescue centres. Wirman thinks games can enrich their lives.

Initially, she spent many hours observing what the orang-utans do when left in small cages with hardly any outside stimulus. She noticed that poking one another with sticks was a recurring game. Back in the lab, she created a plate with holes of various sizes, and sensor-containing sticks that could be poked into the holes, causing the plate to emit various sounds. "It's a music game," says Wirman, who will soon return to Indonesia to test it.

She can't go back to the same young apes, though. At the age of about 2½, orang-utans acquire different interests. "At that age, all they are interested in is exploring their sexuality," she says. So Wirman is switching to another sanctuary

that houses younger animals. "It was either move the project to another centre or start developing sex games for orang-utans," she says. "That would have taken things into a weird kind of direction."

BOREDOM BUSTERS

Elephants, too, might benefit from high-tech toys. Fiona French at the London Metropolitan University is designing gaming devices for them. The project will explore how auditory signals – something that elephants naturally use to communicate – can be incorporated into a kind of video game to enhance their well-being. As well as alleviating boredom in captivity, French thinks games could facilitate our communication with animals.

Michelle Westerlaken at Malmö University in Sweden, who has designed iPad games for cats, believes that video games can amuse bored pets. But she also thinks that games could be a key tool for working out what animals actually prefer when it comes to using gadgets (see main story). "Play is a free activity – you cannot force an animal to play," she says. "So it's a suitable starting point for figuring out how to design things for animals."



researchers consulted experts who work with police and military dogs about the tasks their animals perform and the types of clothing or gear that the dogs typically wear on the job. They then created several different sensors based on dogs' ability to bite, tug, nose-tap and grip things with their mouths. "The dogs know how to use FIDO vests for accomplishing a variety of tasks, just like a human knows how to use a cellphone," says Melody Jackson, the project director.

FIDO allows dogs to communicate specific messages to owners or handlers in a variety of situations. A service dog, for example, can alert its hearing-impaired owner if a tornado siren goes off or the doorbell rings. A rescue dog that locates a lost child could stay with them and call for help by activating a GPS-tagged sensor, rather than running back to its handler. And a bomb-detecting sniffer dog could indicate what type of explosive it has found, and where, then get clear of the area. "FIDO is a game changer for working dog teams," Jackson says. "These highly trained dogs have information that currently they have no way to impart to their handlers."

Give the dog a phone

The FIDO vests contain nine sensors, each of which conveys a different message. Vibrating motors inside the vest can be used to give dogs commands remotely. The researchers tested various breeds, including border collies, golden retrievers, pit bulls, labradors and even Jackson's own little papillon. "We haven't encountered a single dog yet that could not activate all of the sensors," she says.

Jackson designs the gear to ensure the dogs can operate it as easily as possible. "Would you design a button for a cellphone that had to be bitten to operate it? Of course not, because we humans have fingers and thumbs," she says. "Likewise, we wouldn't expect a dog to be able to operate a button on a cellphone designed for humans." They also recently began collaborating with Georgia Tech's K9 bomb sniffer-dog unit. The ensuing trials taught them that they needed to make the vests waterproof. "The first time we tested it, the dog went straight into a lake," Jackson says.

Meanwhile, at the University of North Carolina, Jeff Bozkurt is working on a smart harness that will let dogs collect and transmit data from disaster zones. He thinks such gadgets are just the start. "We'll find new applications for how these animals can help us," he says.

One such application involves teaming dogs



with drones. Anna Gergely at Eötvös Loránd University in Budapest, Hungary, is working on a project called Swarmix, which trains dogs to interact with drones in search and rescue. The aim is to help rescue dogs find survivors as quickly as possible, the idea being that dogs can move much quicker than a human handler, while drones can gather a bird's-eye view of the scene. If the drone detects a victim, it will guide the dog to the spot.

Gergely is learning how to get dogs to work with robots rather than humans or other animals. She put food in a sealed box, which the dogs tried and failed to open. She then introduced a remote-controlled car that opened the box, allowing the dogs to get at the food. Eventually, the dogs began responding to the car as if it were a human handler. Finally, she began using drones in place of the cars. Although the dogs had trouble following high-speed Swinglet drones – a type of surveillance drone with swept-back wings – they adapted well to slower Quadrocopters.

Because they are easy to train, dogs are the obvious starting point. But technology could also provide distraction for bored animals on farms and in zoos (see "Poke to play", above left). Jackson imagines that horses could be another good candidate. "Certainly technology could be used to inform riders if their position is correct, of how much pressure they have on the

Canines on call: the FIDO smart jacket lets service dogs communicate with their handlers

reins and where their weight rests," she says.

Ultimately, though, such work with animals could teach us about our own interaction with technology. Are screens the best we can do? Discarding some of our assumptions could lead to better interfaces – ones based on tactile feedback, for example. Coming up with ways to interact with technology could also help us build devices for pre-verbal infants or cognitively impaired people. Researchers have experimented with different interfaces for tablets used by orang-utans and bonobos, for example, and their insights could improve interfaces for children with dyslexia or impaired vision.

More generally, tech designers have to come up with more ways to get user feedback when the user is an animal – using biometric measures or behavioural studies, for example. Similar techniques could equally be used to evaluate technology intended to be used by people who have difficulty communicating.

For now, Gergely is already seeing ways technology enhances people's relationships with their animals. The owner of a dog that recently took part in one of her robot-interaction trials warned Gergely that the dog was stupid. But the dog ended up doing better than others that had been fully trained. The owner was overjoyed and enrolled her dog in training school. "Now they take walks and have fun together," Gergely says. "In that dog's life, at least, there was a big change." ■

"Working dogs currently have information they can't impart to their handlers"

Rachel Nuwer is a writer based in New York

Random no more

Where do evolution's adaptations come from? **Bob Holmes** finds some big surprises

Arrival of the Fittest: Solving evolution's greatest puzzle by Andreas Wagner, Oneworld Publications, £18.99



EVOLUTION, we have always been told, results from natural selection sifting through countless random variations over millions of years.

That's not good enough, says Andreas Wagner, a systems biologist at the University of Zurich in Switzerland. Natural selection can explain which adaptations survive over time, he argues, but it falls far short of explaining where those adaptations originate.

For over a decade, Wagner has been looking for an answer that would satisfy him, and *Arrival of the Fittest* presents his research to a general audience for the first time. In it, he makes a persuasive case that the origin of adaptations – the arrival of the fittest, rather than the survival of the fittest – can't be down to pure chance alone.

Imagine a vast library, one so big that it contains every possible sequence of letters. Most of the books are gibberish, filled with words like “erwtvaiwq” or “avbqse”, but you can also find *Hamlet* and *On the Origin of Species*. This is the book's core metaphor, used, for example, to describe how most strings of amino acids make non-functional proteins – Wagner's gibberish – but some make working enzymes and a few make brilliant ones.

The problem is that the library is so vast (there are more than 10^{130} different proteins made from just 100 amino acids) that



Arginine dream: how do amino acids turn into superstar proteins?

the odds of evolution stumbling across the specific “book” it needs – an enzyme that can disarm a synthetic toxin, for example – are practically zero. Something else must guide evolution through the library.

Part of the secret, Wagner tells us, is that many different proteins can perform the same function, just as many different books can tell the same story in different words. That is, instead of looking for a single meaningful book in the entire library, evolution is looking for any one of many functionally equivalent ones.

That's not all: the structure of

the library makes it easy for evolution to move from one meaningful book to another. When Wagner and his colleagues tried browsing adjacent “books” – proteins that differ by a single amino acid – they found that most worked just as well as the original. The same was true when they changed another amino acid, and another. In fact, you could move, step by step, from one end of the library to the other without changing the meaning.

This allows populations to accumulate a lot of genetic variation while still remaining viable. In Wagner's metaphor, readers spread into many different rooms of the library. And that's where the big pay-off

comes. By wandering far afield, you come to rooms with very different sorts of books nearby. In real terms, you end up in places where changing just a few more amino acids gives you a protein with a radically different function – an evolutionary breakthrough, close at hand.

And the more hidden variation the population accumulates, the

“Something must guide evolution through the library of possible proteins that the body can make”

more likely that this will happen. As Wagner puts it, “while you walk along one of these trails, the innovation you are searching for will appear at some point in a small neighborhood near you”. That's a big claim, and a far cry from pure, random chance.

In other chapters, Wagner shows that the same principle holds for networks of metabolic and regulatory genes. Indeed, these linked pathways through diverse libraries may turn up in any sufficiently complex system, he says. In what may be the least convincing part of the book, he even speculates that we may be able to apply these principles to algorithms, letting artificial intelligence innovate faster than human inventors ever could.

Whatever the likelihood of that, Wagner's book is an eye-opener. As a bonus, his writing is clear and elegant, with vivid analogies and concrete examples to illustrate his key points. You'll never think about evolution in the same way again. ■

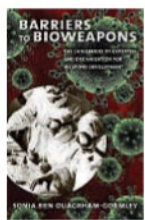
Bob Holmes is a consultant for *New Scientist*

I am floating in space...

This story of our internal navigation system is wonderfully told, says **Jeff Hecht**

Making Space: How the brain knows where things are

by Jennifer M. Groh, Harvard University Press, \$27.95, £20.95



I GREW up using maps. My family moved often, and maps helped me reorient each time. I still turn to them to navigate the tangled streets of

Boston. But my sense of direction comes from spatial orientation, not from memorising a series of right and left turns, which I'm sure to botch somewhere along the line.

Making Space purports to explain how that spatial orientation works. But Jennifer Groh's wonderful book offers a much broader insight into how the senses we think of as separate gather information on our environment, and how nerves and the brain process the information to map our bodies and the world.

Groh starts with vision. To get in the mood, try this. Close your eyes, stretch out your arms, wave your hands, and touch the tip of a finger to the end of your nose. You can't see your fingertip move on its twisted path, but it still reaches its destination with surprising accuracy. Our vision tells us where objects are around us, our nerves where our arms are, and our brains combine that information into the mental map that guides your finger to the tip of your nose.

Hearing is next. Outdoors we can pinpoint the crack of a broken branch or the bang of a car crash because the sound reaches each ear at slightly different times. Presumably, that was good enough to help our ancestors evade hungry lions. But why, Groh

asks, can't we pinpoint the periodic beeps of a smoke detector with a dying battery unless we are in the middle of the room as it beeps? Our sound location system, she concludes, is confused by the noise bouncing off walls, obscuring its original direction.

Our sensory systems have considerable redundancy. You may think your sense of direction comes from your eyes, but much of it comes from fluid-filled structures in your inner ear called the vestibular system. These are nature's gyroscopes and accelerometers that help you keep your balance, and detect how fast and in what direction you are moving. Your muscles may sense which way you're walking, but the vestibular system can tell your direction even if you're in a wheelchair. Alcohol makes you wobbly because it dilutes the liquid in your inner ears, changing

Up, down, left, right: our brains map exactly where we are in the world

the vestibular system's reaction to movement. Motion sickness is the brain's reaction to conflicting signals when your balance system records a ship's motion but your eyes say that you are sitting still.

But our sensory mental maps are more than just a navigation system. Part of the brain called the hippocampus tracks the body's location, a phenomenon called a

"Why can't we pinpoint the beeps of a smoke detector with a dying battery unless we are in the same room?"

place field and discovered in rats by neurologist John O'Keefe in 1971. Damage to the hippocampus prevents it from keeping track of location and forming new factual memories. That explained the case of a man called HM who could not remember events after surgery for epilepsy destroyed much of his hippocampus.

That also explains another legacy of my childhood. I don't

associate memories with a time, but with the house we lived in then. It's a convenient way to order memory that makes good evolutionary sense, helping our ancestors remember where to find food – and avoid predators.

It's a fascinating subject that Groh describes well, with a minimum of polysyllabic bio-speak. It's also an important one. Shortly after I dug into the book, O'Keefe shared the 2014 Nobel prize in physiology or medicine with psychologist-neuroscientist team May-Britt Moser and Edvard Moser. They discovered grid cells, another part of our internal navigation system.

Making Space highlights why they were honoured. More importantly, it explained the complex and essential interaction between the sensory system and the brain, which we are only beginning to understand. ■

Jeff Hecht is a consultant for *New Scientist*



MIHAELA NINIC/PLANET PICTURE



University of Utah
Huntsman Cancer Institute
Department of Oncological Sciences

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The University of Utah Health Sciences Center is a patient focused center distinguished by collaboration, excellence, leadership, and respect. The University of Utah HSC values candidates who are committed to fostering and furthering the culture of compassion, collaboration, innovation, accountability, diversity, integrity, quality, and trust that is integral to the mission of the University of Utah Health Sciences Center.

The University of Utah is an Affirmative Action/Equal Opportunity employer and does not discriminate based upon race, national origin, color, religion, sex, age, sexual orientation, gender identity/expression, status as a person with a disability, genetic information, or Protected Veteran status. Individuals from historically underrepresented groups, such as minorities, women, qualified persons with disabilities and protected veterans are encouraged to apply. Veterans' preference is extended to qualified applicants, upon request and consistent with University policy and Utah state law. Upon request, reasonable accommodations in the application process will be provided to individuals with disabilities. To inquire about the University's nondiscrimination or affirmative action policies or to request disability accommodation, please contact: Director, Office of Equal Opportunity and Affirmative Action, 201 S. Presidents Circle, Rm 135 (801) 581-8365.

The University of Utah values candidates who have experience working in settings with students from diverse backgrounds, and possess a demonstrated commitment to improving access to higher education for historically underrepresented students.



GROWING IANR

Faculty Positions Institute of Agriculture and Natural Resources The University of Nebraska-Lincoln

The Institute of Agriculture and Natural Resources (IANR) at the University of Nebraska-Lincoln (UNL) is committed to world-class excellence in applications of agricultural and life sciences towards a sustained high quality of life for the citizens of Nebraska, and for a quickly growing global population. Early in 2013, reflecting this commitment, IANR launched an initiative to hire new tenure-track faculty members in strategic impact areas of Science Literacy; Stress Biology of Plants, Animals, and Agroecosystems; Healthy Humans; Healthy Systems for Agricultural Production and Natural Resources; and Computational Sciences. This Phase 1 effort was very successful, resulting in the recruitment and hiring of 35 highly skilled tenure-line faculty members (with two searches still active).

We are pleased to announce Phase 2 of this effort with recruitment for an anticipated 30+ additional tenure-line faculty positions. The focus for Phase 2 will be to strengthen the six strategic impact areas in Phase 1, with an additional focus area – Drivers of Economic Vitality for Nebraska.

We invite you to view brief explanations of the positions currently being released and those to be released soon at <http://ianr.unl.edu> to explore whether your skills and experience make you a good fit for our team.

The positions will be advertised and posted beginning December 1, 2014. We invite you to visit the UNL employment web site at <http://employment.unl.edu> to learn which positions are posted.

The University of Nebraska is committed to a pluralistic campus community through affirmative action, equal opportunity, work-life balance, and dual careers.



Opportunities for Informatics Research at

HARVARD MEDICAL SCHOOL

The Biomedical Informatics Research Training (BIRT) Program is a consortium of leading informatics laboratories at Harvard. It is supported by a grant from the National Library of Medicine, National Institutes of Health. For United States citizens and permanent residents, this post-doctoral fellowship provides stipend, tuition, and travel funds. Selected fellows are provided with many opportunities for training, research, interaction, and collaboration. All fellows also pursue the two-year Harvard Medical School Biomedical Informatics MMSc.

The MMSc is a post-doctoral degree program that consists of course work and mentored research. Fellows in our program choose from one of four possible tracks: Bioinformatics; Clinical Informatics; Imaging Informatics; and Population Health Informatics.

To learn more, visit: informaticstraining.hms.harvard.edu/

In addition to the BIRT program, the Center for Biomedical Informatics (CBMI) offers a number of other training and research opportunities.

For more information about our programs, contact
Aimee Doe, Program Coordinator, at Aimee_Doe@hms.harvard.edu

Harvard University

Cambridge, Massachusetts



Tenure-Track Assistant Professorship in Chemistry and Chemical Biology

Candidates are invited to apply for an open-field tenure-track assistant professorship in the Department of Chemistry and Chemical Biology at Harvard University. The appointment is expected to begin on July 1, 2015. The tenure-track professor will be responsible for teaching at the undergraduate and graduate levels. We are seeking candidates who have an outstanding research record and a strong commitment to undergraduate and graduate teaching. Doctorate required by expected start date. Candidates should arrange to have three letters of recommendation sent independently and provide a curriculum vitae, statement of teaching philosophy, list of publications, and outline of their future research plans.

All applications and supporting materials must be submitted via the ARIeS portal (<http://academicpositions.harvard.edu/postings/5829>) no later than December 15, 2014.

Harvard is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, disability status, protected veteran status, or any other characteristic protected by law.

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

2015 The Louisa Gross Horwitz Prize for Biology or Biochemistry

The Louisa Gross Horwitz Prize was established under the will of the late S. Gross Horwitz through a bequest to Columbia University and is named to honor the donor's mother. Louisa Gross Horwitz was the daughter of Dr. Samuel David Gross (1805-1889), a prominent surgeon of Philadelphia and author of the outstanding *Systems of Surgery* who served as President of the American Medical Association.

Each year since its inception in 1967, the Louisa Gross Horwitz Prize has been awarded by Columbia University for outstanding basic research in the fields of biology or biochemistry. The purpose of this award is to honor a scientific investigator or group of investigators whose contributions to knowledge in either of these fields are deemed worthy of special recognition.

The Prize consists of an honorarium and a citation which are awarded at a special presentation event. Unless otherwise recommended by the Prize Committee, the Prize is awarded annually. Dr. James P. Allison, University of Texas MD Anderson Cancer Center was the 2014 awardee.

Qualifications for the award

The Prize Committee recognizes no geographical limitations. The Prize may be awarded to an individual or a group. When the Prize is awarded to a group, the honorarium will be divided among the recipients, but each member will receive a citation. Preference will be given to work done in the recent past.

Nominations must be submitted electronically at: <http://www.cumc.columbia.edu/research/horwitz-prize>

All communications and materials must be written in the English language.

Deadline date: January 30, 2015

Re-nomination(s) are by invitation only. Self-nominations are not permitted.

Nominations should include:

- 1) A summary, no more than 500 words long, of the research on which this nomination is based.
- 2) A summary, no more than 500 words long, of the significance of this research in the fields of biology or biochemistry.
- 3) A brief biographical sketch of the nominee, including positions held and awards received by the nominee.
- 4) A listing of up to ten of the nominee's most significant publications relating to the research noted under item 1.
- 5) A copy of the nominee's curriculum vitae.

POSTDOCTORAL OPPORTUNITIES

Find these and many more postdoctoral opportunities on our New Scientist Jobs online jobs board!

Go to www.NewScientistJobs.com

Enter the Job ID# listed below to read about the position. Find more jobs by entering your criteria into the grey search box.

- 1401536519** C V Starr Fellowships in Neuroscience- Princeton, NJ - **PRINCETON NEUROSCIENCE INSTITUTE**
1401535617 Research Associate II - **MASSACHUSETTS INSTITUTE OF TECHNOLOGY/BROAD INSTITUTE**
1401534831 Research Scientist I - **MASSACHUSETTS INSTITUTE OF TECHNOLOGY/BROAD INSTITUTE**
1401537337 Postdoctoral Fellow Opportunities- Geisinger Translational and Molecular Medicine Program- PA, **GEISINGER HEALTH SYSTEM (GHS)**
1401530716 Postdoctoral Research Position, Computational Imaging- Tucson, AZ - **UNIVERSITY OF ARIZONA, DEPT. OF ELECTRICAL AND COMPUTER ENGINEERING**
1401490263 Staff Scientists and Engineers, Research Assistants, and Postdoctoral Fellows - **THE WYSS INSTITUTE FOR BIOLOGICALLY INSPIRED ENGINEERING AT HARVARD UNIVERSITY**
1401490259 NASA Postdoctoral Program (NPP) Oak Ridge Associated Universities - **NASA POSTDOCTORAL PROGRAM**
1401537719 Research Fellow - Silver Spring, MD **HENRY M JACKSON FOUNDATION**
1401537536 Immediate Opening for Postdoctoral/Research Associate Level Tumor Immunologist- **RI VEROSCIENCE**
1401537535 Immediate Opening for Postdoctoral/Research Associate Level Neurophysiologist- **RI VEROSCIENCE**
1401537534 Immediate Opening for Postdoctoral/Research Associate Level Metabolic Physiologist- **RI VEROSCIENCE**
1401540029 Research Associate III (Antigen Production) - **THERMO FISHER**
1401539341 Research Associate IV - **THERMO FISHER**
1401539796 Research Associate III (Molecular Biology) - **THERMO FISHER**
1401540339 Research Associate III - Cell Biology - **THERMO FISHER**
1401540144 Senior Research Associate Job - **CELGENE**
1401540143 Research Associate Job - **CELGENE**
1401535700 Post Doc Fellowship - Computational Chemistry Job - **CELGENE**
1401540133 Post-Doctoral Fellow, Regenerative Biology - Madison, WI - **MORGRIDGE INSTITUTE FOR RESEARCH**
1401539147 Postdoctoral Position - Vascular Ion Channels- Memphis, TN - **UNIVERSITY OF TENNESSEE MEMPHIS HEALTH SCIENCE CENTER**
1401538980 Post-Doctoral Fellow in Water Resources- Miami, FL - **FLORIDA INTERNATIONAL UNIVERSITY-**
1401536702 Postdoctoral MERIT Program - Birmingham, Alabama - **UNIVERSITY OF ALABAMA AT BIRMINGHAM (UAB), OFFICE OF POSTDOCTORAL EDUCATION**
1401533598 Assistant Professor, Sustainable Vegetable Production & Nutrition Systems- East Lansing, MI - **MICHIGAN STATE**
1401487465 Opportunities at Lerner Research Institute- Cleveland, OH - **CLEVELAND CLINIC FOUNDATION, LERNER RESEARCH INSTITUTE**
1401490255 Grant Programs, Scientific Research and Teaching - **BURROUGHS WELLCOME FUND**
1401531180 2015 Postdoctoral Fellowship Program- Moss Landing, CA - **MONTEREY BAY AQUARIUM RESEARCH INSTITUTE (MBARI)**
1401532274 Fellowships For Postdoctoral Scholars, Variety Of Research Areas- Woods Hole, Ma - **WOODS HOLE OCEANOGRAPHIC INSTITUTION**



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NewScientist Jobs



A. JAMES CLARK
SCHOOL OF ENGINEERING

PROFESSOR AND CHAIR THE FISCHELL DEPARTMENT OF BIOENGINEERING UNIVERSITY OF MARYLAND, COLLEGE PARK

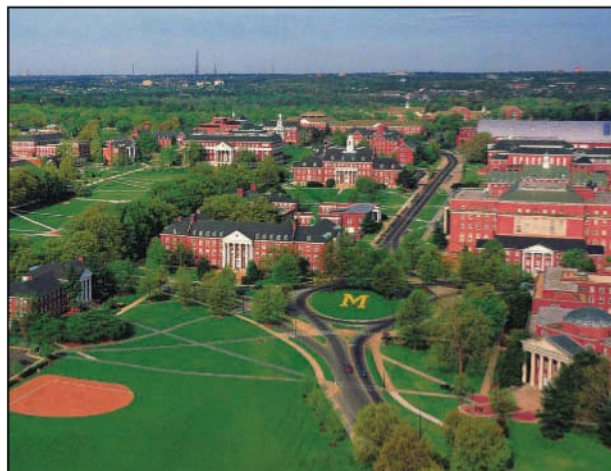
Applications are invited for the position of Chair of the Fischell Department of Bioengineering at the University of Maryland. Responsibilities include leadership of a research-active academic department, program development with industrial partners, government labs and foundations, and stewardship of strong academic programs. Applicants should have an earned doctorate in bioengineering or a closely related field; leadership ability with excellent interpersonal skills; a proven research record with international recognition; and a commitment to engineering education. Applicants must be qualified for appointment as a tenured full professor in the Department.

In 2017, the Fischell Department of Bioengineering will move into A. James Clark Hall. This 184,000-square-foot building will house world-class research and educational facilities and the Robert E. Fischell Institute for Biomedical Devices <http://www.eng.umd.edu/clarkhall/>. The Fischell Department of Bioengineering

currently has 20 regular faculty (with plans to expand), 17 affiliate faculty members and 9 staff members, 400+ undergraduate students, 75 graduate students and more than \$8 million in annual research expenditures. More information at: <http://www.bioe.umd.edu>. Questions can be addressed to: Chair-SearchComm-BIOE@umd.edu.

For best consideration, applications should be submitted to <http://ejobs.umd.edu/postings/30410> (Position number 105571) by 1/30/2015. Applications should include a cover letter, complete curriculum vitae (resume), and contact information for five references.

The University of Maryland is an equal opportunity affirmative action employer.



Monterey Bay Aquarium Research Institute

2015 POSTDOCTORAL FELLOWSHIP PROGRAM

Applications for the postdoctoral fellowship program at the Monterey Bay Aquarium Research Institute (MBARI) are currently being accepted. MBARI is dedicated to the development of state-of-the-art instrumentation, systems, and methods for scientific research in the oceans. Ongoing programs in marine robotics, ocean physics, chemistry, geology, and biology as well as information management and ocean instrumentation research and development exist at MBARI. Located in Moss Landing, California at the head of Monterey Canyon, MBARI enjoys convenient access to diverse oceanographic environments. The institute operates research vessels equipped with remotely operated vehicles, autonomous underwater vehicles, and diverse oceanographic equipment. In addition, MBARI operates the MARS seafloor cabled observatory. MBARI is a non-profit oceanographic research institute supported by the David and Lucile Packard Foundation.

Offers will be made to candidates from the fields of biological, chemical, and physical oceanography; marine geology; and ocean engineering. Candidates must be awarded the Ph.D. degree prior to commencing the two-year appointment and start during the 2015 calendar year. Applicants are encouraged to communicate with potential research sponsors at MBARI for guidance on project feasibility, relevance to ongoing research projects, and resource availability (http://www.mbari.org/about/postdoc_mentors.htm).

Application deadline: Wednesday, December 10, 2014

Selected candidates will be contacted in early March 2015.

Application requirements:

1. Curriculum vitae
2. At least three professional letters of recommendation
3. Succinct statement of the applicant's doctoral research
4. Potential research goals at MBARI
5. Supplemental information online form (http://www.mbari.org/oed/jobs/forms/postdoc_form_2015.htm)

Address your application materials to:

MBARI, Human Resources

Job code: Postdocs-2015

7700 Sandholdt Road, Moss Landing, CA 95039-9644

Submit by e-mail to jobs_postdocs@mbari.org (preferred), by mail, or by fax to (831) 775-1620.

EOE

MBARI Welcomes Diversity

MBARI is an equal opportunity and affirmative action employer. MBARI considers all applicants for employment without regard to race, color, religion, sex, national origin, age, disability, or covered veteran status in accordance with applicable federal, state, and local laws.

Competitive compensation and benefits package.

Fellowships for Postdoctoral Scholars

Woods Hole Oceanographic Institution



New or recent doctoral recipients with research interests associated with the following are encouraged to submit scholarship applications prior to January 5, 2015.

Departments - Awards related to the following areas are anticipated: Applied Ocean Physics & Engineering; Biology; Geology & Geophysics; Marine Chemistry & Geochemistry; Physical Oceanography; and in cooperation with the USGS laboratory located on the WHOI campus.

Institutes - Each Institute fosters interdisciplinary research addressing critical issues, and we will award a scholarship to support related research: Ocean and Climate Change Institute; Coastal Ocean Institute; Ocean Exploration Institute; Ocean Life Institute.

The Center for Marine and Environmental Radioactivity (CMER) will award a fellowship for research on natural and human-made radioactive substances in the environment including the study of their sources and fate or use as tracers of ocean processes.

Awards are competitive, with primary emphasis placed on research promise. Scholarships are 18-months with an annual stipend of \$58,000, a research budget and eligibility for health and dental insurance. Recipients are encouraged to pursue their own research interest in association with resident staff. Communication with potential WHOI advisors prior to submitting an application is encouraged.

Further information may be obtained at:

www.whoi.edu/postdoctoral

An Equal Opportunity/Affirmative Action Employer





Working with clients and partners, the National Research Council Canada provides strategic research, innovation support, scientific and technical services to develop and deploy solutions to meet Canada's current and future industrial and societal needs. Guided by our core values of impact, accountability, leadership, integrity and collaboration, NRC is a dynamic and vibrant organization that, in its ongoing evolution, is seeking multiple research positions with our Human Health Therapeutics (HHT) Portfolio.

The NRC HHT Portfolio is a globally recognized leader in the field of biologics and vaccine development, including the delivery of large molecules to the brain. NRC HHT adds value to partners' products by overcoming challenges in target selection, candidate design, lead optimization, functional and biophysical characterization, and bioprocessing. For more information on working at NRC and with Human Health Therapeutics go to

<http://www.nrc-cnrc.gc.ca/eng/rd/hht/index.html>

We are looking for motivated Team Leaders in the following areas:

Team Leader - Single Domain Antibodies

Competition #122-14-0217 Ottawa, Ontario English

Team Leader - Cancer Immunology

Competition #122-14-0265 Ottawa, Ontario English

Team Leader - Biophysical Assays and Characterization of Biologics

Competition #122-14-0289 Montréal, Québec Bilingual BBB/BBB

Team Leader - Animal Cell Scale-up

Competition #122-14-0360 Montréal, Québec Bilingual BBB/BBB

Section Head - Process Development and Scale-up

Competition #122-14-0362 Montréal, Québec Bilingual BBB/BBB

To apply for any of these roles go to

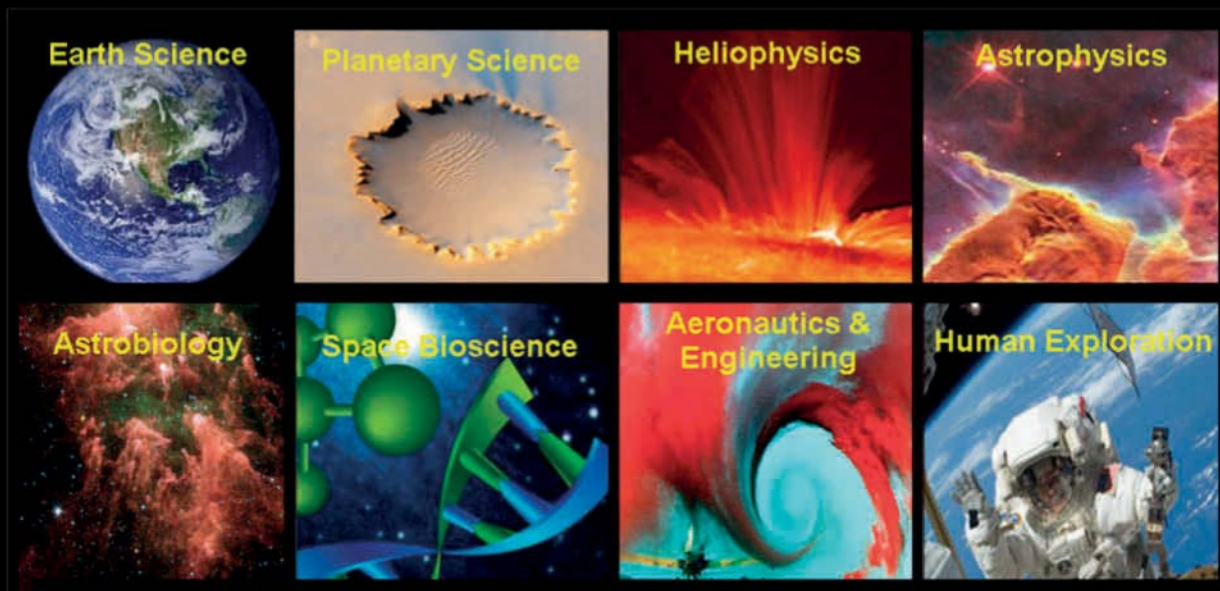
<http://www.nrc-cnrc.gc.ca/eng/careers/competitions/index.html>



NASA

Postdoctoral Program

administered by Oak Ridge Associated Universities



The NASA Postdoctoral Program (NPP) supports NASA's goal to expand scientific understanding of Earth and the universe in which we live.



The NASA Postdoctoral Program offers unique opportunities to engage in NASA research in Earth science, planetary science, heliophysics, astrophysics, aeronautics, human exploration, space bioscience, and astrobiology.

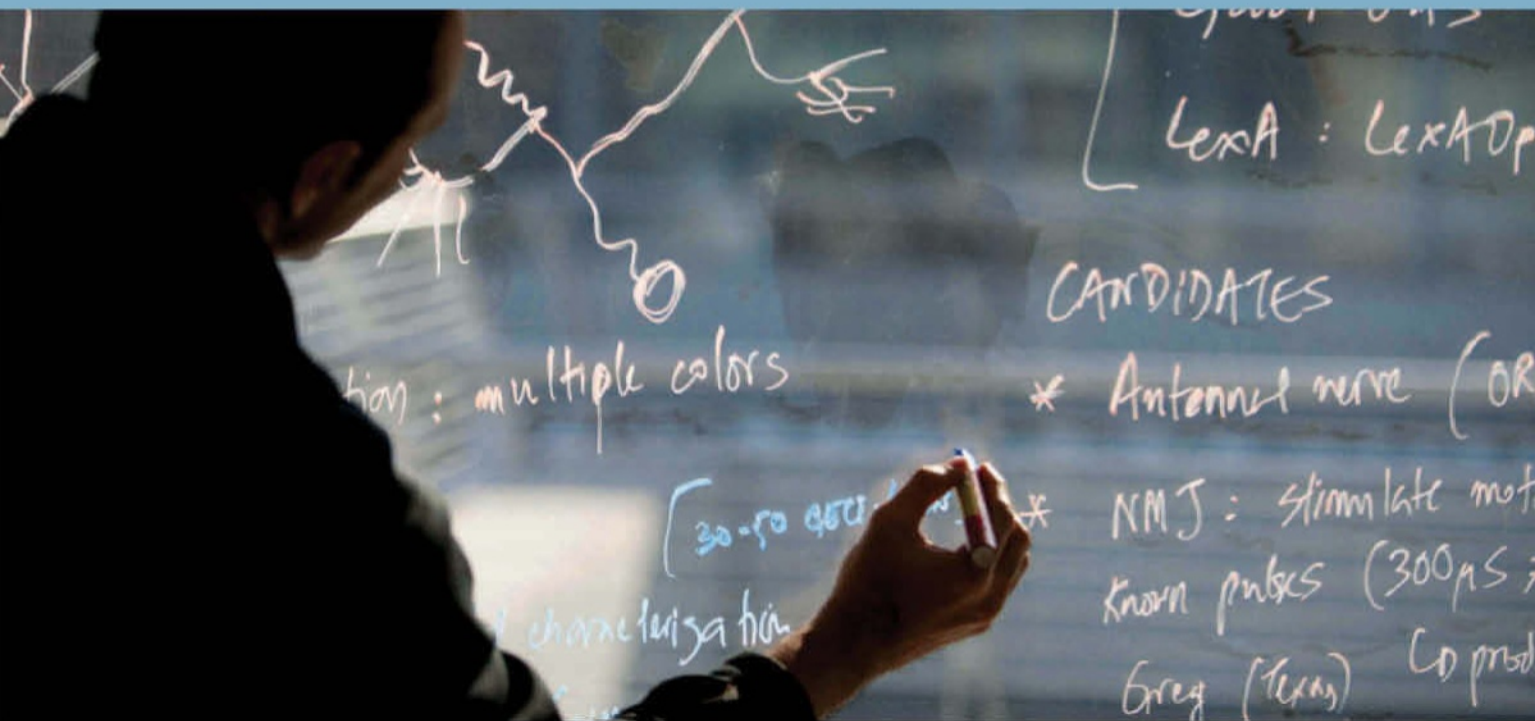
Details

- Annual stipends start at \$53,500, with supplements for high cost-of-living areas and certain degree fields
- Annual travel budget of \$8,000
- Relocation allowance
- Financial supplement for health insurance purchased through the program
- Appointments renewable for up to three years
- Approximately 90 Fellowships awarded annually

Application Deadlines

Three each year - March 1, July 1, and November 1

Apply at <http://nasa.orau.org/postdoc>



EXTRAORDINARY SCIENTIFIC OPPORTUNITIES

HHMI's Janelia Farm Research Campus is a pioneering biomedical research complex where scientists from diverse disciplines use emerging and innovative technologies to investigate biology's most challenging problems. Janelia invites applications from bold, imaginative scientists.



Photos by Matt Staley



Find out more and apply:
www.janelia.org/2014

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WITH typical topicality we turn up a message Lance Andrewes sent in January. It being about the “most read” section on the BBC News website, our delay is appropriate. When Lance looked, the second slot was occupied by “World’s tallest man saves dolphin” – a story from CBBC, the British broadcaster’s service for children, published in December 2006.

Typically, we concluded with Lance, such things happen when someone on an over-popular website says “Lookee here!” and the throng follows. We cannot rule out campaigns to make stories reappear from the past.

Lance thinks the phenomenon needs a name. “Repopular” sounds, he concedes, “lame, but it’s all I can think of. I’m too busy reading old stories.” Feedback is torn between “revenant news”, “revenant kittens” and “olds”. Any better ideas?

ANACHRONISMS will become ever more frequent with the advent of displays that provide

people with “information about the landmarks, buildings and businesses they are looking at in the real world”, as predicted in our report on Google’s Knowledge Vault (23 August p 18).

Erik Wahlström wondered how this system will be financed, and concludes: “By advertising. Of course.” This may be fun. We hope for a software plug-in inspired by the 1988 John Carpenter film *They Live*, whose hero discovers a pair of sunglasses that automatically display billboards’ real messages: “Consume”, “Obey”, “Watch TV.”

IT IS not often that Feedback receives a message from a reader that contains the phrase “my acupuncturist”. John Cleveland explains that he has a painful condition. The US Medicare scheme will not pay for newer and more expensive patented pain relievers. The state of Indiana, ever vigilant in case drugs should be enjoyed, or used to relieve non-

physical pain, last year imposed strict conditions on doctors prescribing opioid drugs.

So in order to continue his prescription John is required to see “a pain manager, a psychiatrist, a psychologist, an acupuncturist/massage therapist, and others”. He “cannot say that acupuncture works. It is just a hurdle I must clear.”

There must be a better way. There is, and it reminds Feedback to value the UK’s National Health Service.

WE CAN now turn to the tale of a salescreature trying to sell John Cleveland’s acupuncturist (above) a “Healing System” that “creates photon and amplified negative free electron energies passing through vials of multi-botanical solutions”. The curious device, at halo4u.com, bears a remarkable superficial resemblance to a chrome flashlight.

How might it work? “Photon energy is capable of carrying the harmonics or vibrational frequencies of the contents of any liquid through which it passes,” the website assures us. It is reticent about claiming cures: but apparently the salescreature said it could cure concussion. To the acupuncturist’s credit, John reports that “she gently showed them the door”.

SUBSCRIBERS to the British Film Institute’s *Sight & Sound* magazine are told that “we are unable to make the printed index a continued resource”, but it will be available to download. “If you do not have access to a computer,” the BFI continues, helpfully, “then please contact us and we can arrange for a printed copy to be posted to you”. And how would you make contact if you lack access to a computer? By emailing s&s@bfi.org.uk of course.

PEOPLE for the Ethical Treatment of Animals (PETA) crows that catering for London’s Somerset House ice-skating rink is now “foie gras-free” and that this “undoubtedly reflects the wish of the majority of the members

of the public, who want to see the sale of this vile French product banned in the UK”.

Hang on. Why overshadow an argument about harm to animals by stressing that the product is French? We feel incited to form a popular society for the ethical treatment of France, to be known by its nearly-pronounceable French acronym, SPTEF.

INTRIGUED by our consideration of the properties, if any, of “ineffable numbers” (1 November), a reader requests permission to “lower the tone of your numbers discussion”. Their car, registered in 1960, bears the identifier “LSL 929”. This, they observe, is “a double palindrome”. Further, “the number part is the highest palindromic prime below 1000.” Do any readers also have interesting numbers?



ANONYMITY seemed best for the reader mentioned above. People have been exercised enough about car number plates being publicly associated with a name or location for them to campaign successfully for plates to be blurred out in online imagery.

Feedback had presumed that there is some risk of identity theft, or similar. But we now realise that we have no idea how the feared scam would work. Purely in the interests of logical completeness – can you help?

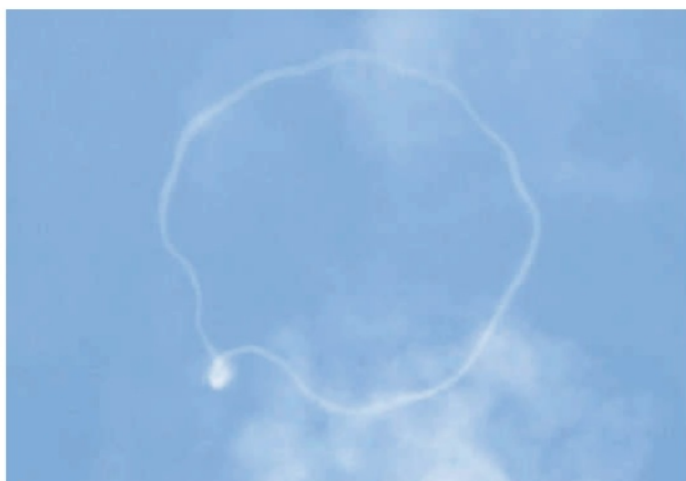
You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week’s and past Feedbacks can be seen on our website.

“Non-urgent X-rays hit by strike” read a *Dundee Courier* headline on 13 October. Ian Davidson knows the subject is serious, but he still likes the idea of lackadaisical light

Ring of confusion

This photograph (right) was taken on 22 June this year in north Pembrokeshire, UK. There were aircraft trails in the sky – but all of them were absolutely straight. So what is this?

■ That is undoubtedly an aircraft condensation trail (contrail), made quite deliberately. The dense knot in the bottom left is where the aircraft was climbing (or descending) almost vertically, concentrating the contrail in one spot. The aircraft levelled off, then turned abruptly before starting the circle. Once it had arrived back at the knot, it closed the loop by descending (or climbing) steeply. The transition between vertical and horizontal circling is evident



Leather and steel

As a boy I watched my grandfather sharpen his cut-throat razor on a leather strap. How did this work?

■ Stropping a blade on a leather strap (or strop), as described, is supposed to smooth out indentations without removing any metal.

In contrast, sharpening a blade on a whetstone removes any

metal bent out of alignment.

The leather is usually impregnated with an abrasive compound like jeweller's rouge or green chromium (III) oxide. To avoid cutting or nicking the strop while achieving a sharp edge, the correct technique is required: the razor has to be drawn spine first along the leather.

Mike Follows

Sutton Coldfield, West Midlands, UK



"A complex series of manoeuvres produced a good aerial representation of the male anatomy"

in the convex shape of the trail at this point.

An old friend of mine was a navigator in two-seater fighter aircraft. He told me how, on a day when conditions were ideal for contrails to persist, he navigated his pilot through a complex series of manoeuvres and produced a good representation of the male anatomy. His aerial graffiti was apparently visible (but not necessarily appreciated) over a large area of southern England.

Jack Harrison

Tobermory, Isle of Mull, UK

The writers of answers that are published in the magazine will receive a cheque for £25 (or US\$ equivalent). Answers should be concise. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and an email address if you have one. New Scientist retains total editorial control over the published content.

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Unanswered questions can also be found at this URL.

This week's questions

COMPOUND EYELINE

Drivers can easily be dazzled when the sun is low in the sky ahead. We can cope with this by shading our eyes with one hand, for example, but how do insects manage? On a clear day, some sections of their compound eyes must, unavoidably, end up pointed directly at the sun. How do insects maintain effective vision in that direction while avoiding damage of the kind that mammals' eyes could all too easily suffer?

Sandy Henderson

Dunblane, Stirling, UK

FLY AWAY HOME?

Why are some small creatures unafraid of humans? If a bee, ladybird or praying mantis settles on my hand, they seem most reluctant to leave. But I have yet to experience lingering contact with a butterfly, small reptile or bird. Why the difference?

Janet Le Page

Johannesburg, South Africa

SEEDS OF DOUBT

Can anyone solve a mystery several decades old by identifying these seed pods (see photo, left)? They were collected on a beach just north of the town of Budva, in what is now Montenegro, in August 1967. A stream ran down to the beach from a marshy valley, and there were wooded hills on either side.

Jane Spooner

Toronto, Canada

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OMEGA



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OMEGA launched the original Seamaster 300 in 1957. An instant classic, it was admired by generations of divers and underwater professionals. More than half a century later, it has been completely upgraded and enhanced. While the completely anti-magnetic Seamaster 300 Master Co-Axial honours an iconic ancestor, it is destined to make a splash in its own right.

Ω
OMEGA
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